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(71) Applicants and

(72) Inventors: BENENSON, James, Jr. [US/US]; 1 Lexington Avenue, New York, NY 10010 (US). LAING, David, A. [US/US]; 217 Northfield Drive, Elyria, OH 44035 (US).

(74) Agent: SLOMOWITZ, Scott, M.; Caesar, Rivise, Bernstein, Cohen & Pokotilow, Ltd., Seven Penn Center, 12th floor, 1635 Market Street, Philadelphia, PA 19103-2212 (US).

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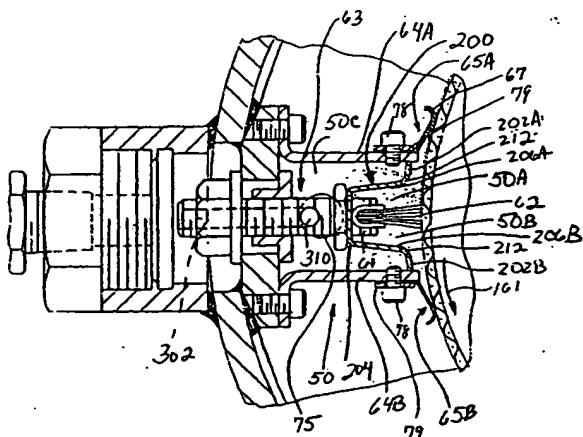
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(54) Title: SELF-CLEANING FUEL OIL STRAINER



(57) **Abstract:** A self-cleaning fuel oil strainer, coupled to a continuous fuel flow, that includes a pair of canisters, each having a cylindrical wedge wire fuel oil filter screen. An elongated brush running the length of the screen is disposed between two confining walls also running the length of the screen to form a chamber. An elongated partition, including two sets of apertures, is used, along with the elongated brush, to divide the chamber into two particulate dislodge chambers and a drain subchamber. A drain is in fluid communication with the drain subchamber. During cleaning, the drain is opened and the screen is rotated against the brush for liberating the particulate contaminants and a limited amount of fuel oil into the two dislodge subchambers. The particulate contaminants and the limited amount of fuel oil then pass through the apertures at a high velocity and into the drain subchamber which exits through the drain. Alternatively, a reverse flow of clean fuel oil can be used in combination with the elongated brush, for dislodging the particulate contaminants from the fuel oil filter screen. Finally, another variation of using a reverse flow of clean fuel oil for cleaning purposes is discussed whereby a stationary fuel oil strainer is disposed in a system that isolates the fuel oil strainer from the normal fuel oil flow during cleaning.

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SELF-CLEANING FUEL OIL STRAINER

SPECIFICATION

BACKGROUND OF THE INVENTION

This invention relates generally to filter devices and, more particularly, to fuel system filters for small particulate contaminants.

It is well-known that the mechanical cleaning of a filter surface can be accomplished by having a brush or scraper drag along the filter surface where deposits have accumulated. In certain configurations, the brush or scraper is mounted at one end between two walls but with a significant portion of the brush or scraper projecting beyond the walls. Such configurations are shown in U.S. Patent Nos. 148,557 (Gillespie et al.); 556,725 (Farwell); 740,574 (Kohlmeyer) and 793,720 (Godbe). In conventional filter systems, the particulate contaminants are driven off the filter surface and are deposited in a hopper or tank along with the fluid being filtered, thus discarding large amounts of the fluid being filtered.

The use of a brush, or high speed cleaning spray, disposed between a pair of walls for cleaning a cylindrical filter is known in the art, as is disclosed in U.S. Patent Nos. 5,423,977 (Aoki et al.) and 5,595,655 (Steiner et al.) and Swiss Patent No. 22,863 (Zingg). Another variation employs a backwash that drives the particulate contaminants off of the cylindrical filter, as is disclosed in U.S. Patent No. 3,338,416 (Barry).

One desirable use for fuel oil filter systems of the present invention is in ships. Prior art ship fuel oil systems use conventional filter cartridges for cleaning the fuel in-line. However, these filter cartridges require frequent replacement which, in turn, requires the fuel flow to be interrupted during replacement. Interruption of the fuel oil flow will shut down the ship's main engines, thereby rendering the ship incapable of maneuvering. This can be catastrophic where the ship is in tight quarters, e.g., during docking or navigating through narrow passageways, or during storms, or during battle with regard to warships. Furthermore, there are additional costs of having to store sufficient replacement cartridges onboard, the logistics involved in shipping and disposing the cartridges to and from the ship, and the labor costs involved in replacing the cartridges.

In addition, shipboard fuel oil straining is a specialized straining process. In particular, the fuel oil flow is initially pre-strained for gross particulate contaminants, such that any particulate contaminants remaining in the fuel oil flow are extremely small (e.g., < 100 microns, with a large percentage being less than 25 microns). As a result, where these small particulate contaminants are captured by a downstream strainer (e.g., a wedge wire screen strainer), both on and within the strainer surface, and then later dislodged during the strainer cleaning process, these extremely small particulate contaminants do not fall by gravity toward a drain but remain suspended in the fuel oil and will re-attach to the strainer surface. Therefore, there remains a need for a cleaning device that can dislodge such extremely small particulate contaminants off of the downstream strainer surface, as well as from within the strainer surface, and then ensure that these particulate contaminants flow out through the drain rather than re-attaching to the strainer surface.

Thus, there is a need for an improved system for removing undesired particulate contaminants from a fuel oil flow and without interrupting that fuel oil flow to the engines, while minimizing the amount of fluid removed therewith. It is to just such a system that the present invention is directed.

OBJECTS OF THE INVENTION

Accordingly, it is the general object of the instant invention to provide a fuel oil cleaning device that overcomes the problems of the prior art.

It is a further object of this invention to provide a fuel oil cleaning device that permits continuous fuel oil flow even during the cleaning process.

It is a further object of this invention to provide a fuel oil cleaning device that removes small particulate contaminants from a strainer surface, and from within the strainer surface, and ensures that when these small particulate contaminants are dislodged from the strainer during cleaning that they enter a drain rather than re-attaching to the strainer surface.

It is still yet another object of this invention to provide a fuel oil cleaning device that generates a high velocity flow of dislodged particulate contaminants away from the strainer and into a drain.

It is a further object of this invention to provide a fuel oil cleaning device that minimizes the amount of fuel oil that must be discarded during cleaning.

It is still yet a further object of this invention to eliminate the need for frequent replacement of the fuel oil filter.

It is still another object of this invention to minimize the costs associated with frequent fuel oil filter replacements.

It is still yet even another object of this invention to improve the efficiency of particulate removal.

It is still yet another object of this invention to provide a fuel oil filter that can be self-cleaned with the use of a reverse flow of clean fuel oil.

It is even yet another object of this invention to provide a self-cleaning fuel oil filter system that permits the fuel oil filter element to remain stationary during cleaning.

SUMMARY OF THE INVENTION

These and other objects of the invention are achieved by providing a fuel oil cleaning device disposed within a continuous fuel oil flow having particulate contaminants therein. As mentioned earlier, the particulate contaminants that need to be removed from the fuel oil flow are extremely small, less than 100 microns, and a large percentage of these less than 25 microns, therefore do not settle out by gravity. The invention of the present application is well-suited to removing these small particulate contaminants from the fuel oil flow and into a drain. The cleaning device comprises a porous member in fluid communication with the fuel oil flow such that the fuel oil flow enters the porous member through a first porous member surface and exits through a second porous member surface and wherein the fuel oil flow deposits the particulate contaminants on the first porous member surface. The cleaning device further comprises particulate-removing means (e.g., a brush, a scraper, or equivalent device, or a reverse flow of clean fuel oil, or any combination of these for removing particulate contaminants from the porous member) disposed to be in close proximity with the first porous member surface for removing particulate contaminants from the first porous member surface along substantially the entirety of the length of the first porous member surface. The cleaning device also comprises a drive mechanism for displacing the porous member such that the particulate-removing means dislodges the particulate contaminants from the first porous member surface during the displacement. In addition, the cleaning device includes a pair of flow confining walls

disposed to be in close proximity with the first porous member surface along substantially the entirety of the length of the first porous member surface for defining a chamber for confining the removed particulate contaminants therein. The particulate-removing means is positioned within the chamber. The cleaning device also comprises a drain that is in communication with the chamber and through which the dislodged particulate contaminants are removed when the drain is opened. The cleaning device further comprises a partition that divides the chamber into a first subchamber and a second subchamber along the length of the chamber and wherein the drain is in communication with the second subchamber. The partition includes a plurality of apertures for passing the dislodged particulate contaminants from the first subchamber into the second subchamber. The plurality of apertures is of sufficient area to generate a rapid velocity of dislodged particulate contaminants from the first subchamber to the second subchamber.

The term continuous fuel oil flow is defined as a fuel oil flow that is uninterrupted, regardless of the fuel system cleaning function status.

Where the particulate-removing means is a mechanical means (e.g., a brush or scraper), it is functional within the confines of the pair of walls. Where the particulate-removing means comprises a reverse flow of clean fuel, the reverse flow is opposite the pair of confining walls and the reverse flow is directed from the second porous surface to the first porous surface.

The above invention also includes a method for cleaning a fuel oil flow having particulate contaminants therein. The method comprises the steps of: disposing a porous member in fluid communication with the fuel oil flow such that the fuel oil flow enters the porous member through a first porous member surface and exits through a second porous member surface so that the fuel oil flow deposits the particulate contaminants on the first porous member surface; positioning a pair of flow confining walls adjacent the first porous member surface to define a chamber; positioning a particulate-removing means within the chamber and closely-adjacent the first porous surface member; dividing the chamber into first and second subchambers with a partition wherein the particulate-removing means is disposed in the first subchamber and the second subchamber is in fluid communication with a drain when the drain is opened; providing a plurality of apertures in the partition to provide fluid communication

between the first and second subchambers; and displacing the porous member to permit the particulate-removing means to dislodge particulate contaminants trapped on the first porous member surface into the first subchamber; and opening the drain to generate a rapid velocity of dislodged particulate contaminants through the plurality of apertures into the second subchamber and out into the drain.

Another embodiment of the present invention comprises a fuel oil cleaning system and method that uses a reverse flow of clean fuel oil for cleaning a stationary porous member disposed in a fuel oil flow. To that end, the system comprises an inlet valve for controlling the fuel oil flow having particulate contaminants therein; the system also comprises a porous member having an input coupled to the inlet valve and wherein the porous member is in fluid communication with the fuel oil flow such that the fuel oil flow enters the porous member through a first porous member surface and exits through a second porous member surface. The fuel oil flow deposits the particulate contaminants on the first porous member surface and the fuel oil flow exits through the second porous member surface defining a clean fuel oil flow that flows out of the porous member at an output; the system further comprises an outlet valve coupled to the output for controlling the clean fuel oil flow; the system further comprises flow control means (e.g., a purge valve or other passive components such as a check valve and a flow restricting orifice) having a flow control means input coupled to a source of clean fuel oil and a flow control means output coupled to the output. The flow control means controls a reverse flow of the clean fuel oil from the second porous member surface through the first porous member surface for dislodging the particulate contaminants from the first porous member surface to form a contaminated reverse flow of fuel oil; the system further comprises a drain valve coupled to the input for directing the contaminated reverse flow of fuel oil; and finally, the system operates whereby the inlet valve and outlet valve are closed during cleaning and the flow control means and the drain valve are opened during cleaning.

The above invention also includes a method for cleaning a fuel oil flow having particulate contaminants therein. The method comprising the steps of: disposing a porous member in fluid communication with the fuel oil flow such that the fuel oil flow enters the porous member through a first porous member surface and exits through a second porous member surface so that the fuel oil flow deposits the

particulate contaminants on the first porous member surface; isolating the porous member from the fuel oil flow; sending a reverse flow of clean fuel oil through the porous member from the second porous surface member surface to the first porous member surface for dislodging the particulate contaminants from the first porous member surface to form a contaminated reverse flow of fuel oil; opening a drain to receive the contaminated reverse flow of fuel oil; and recoupling the porous member to the fuel oil flow.

DESCRIPTION OF THE DRAWINGS

Other objects and many of the intended advantages of this invention will be readily appreciated when the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawings wherein:

Fig. 1 is a block diagram of the fuel oil system in which the present invention is located;

Fig. 2 is a top view of the present invention;

Fig. 3 is a partial side view of the present invention;

Fig. 4 is a bottom view of the present invention;

Fig. 5 is a cross-sectional view of the present invention taken along line 5-5 of Fig. 2;

Fig. 6 is partial sectional view taken along line 6-6 of Fig. 5;

Fig. 7 is a partial sectional view taken along line 7-7 of Fig. 5;

Fig. 8 is a cross-sectional view of the present invention using a reverse flow of clean fuel oil as part of the particulate-removing means;

Fig. 9 is a partial sectional view taken along line 9-9 of Fig. 8;

Fig. 10 is similar to Fig. 9 except that a different reverse flow direction is depicted;

Fig. 11 is an enlarged, cross-sectional view of a portion of Fig. 5, depicting different portions of the partition and one of the associated wipers;

Fig. 12 is an enlarged, cross-sectional view of a portion of Fig. 5, depicting the passageways in the particulate-removing means support for use with the alternative drain configuration;

Fig. 13 is a partial isometric view of the internal particulate chamber depicting the partition and one of the wipers comprising the shoes;

Fig. 14 is a schematic of a fuel oil cleaning system using a stationary fuel oil strainer;

Fig. 15 is a variation of the fuel oil cleaning system of Fig. 14 wherein the downline fuel flow is used as the source of the reverse clean oil fuel flow; and

Fig. 16 is another variation of the invention of Fig. 15.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

The following is a detailed description of the present invention. The present invention has wide application where straining very small particulate contaminants, less than 100 microns and large percentage of these are less than 25 microns, from a fuel oil flow is required, and is not limited to the environment shown in Fig. 1, as will be discussed in detail below. The present invention is characterized as a non-disposable cleaning device, i.e., having a porous member that can be cleaned rather than being thrown away. The term non-disposable is defined as an item that does not require periodic replacement, e.g., once a day, week or month. Thus, such a non-disposable item has obvious advantages in environments where storage is limited and cleaning device replenishment facilities are unavailable, e.g., ocean-going vessels. Other example systems include power plants, cogeneration facilities, etc.

As an exemplary environment, Applicants have depicted a ship fuel oil system for disclosing the preferred embodiment. Referring now in greater detail to the various figures of the drawing, wherein like reference characters refer to like parts, there is shown in Fig. 1 at 20 an oil strainer of the present invention. The oil strainer 20 forms part of a compensated fuel system for use on watercraft, e.g., ships and boats. The compensated fuel oil system comprises a fuel oil service subsystem which includes a service tank 24 which is filled daily from a main fuel storage tank 22 with approximately one day's amount of fuel. The flow of fuel from the service tank 24 to the engine (which in the preferred embodiment is either a gas turbine or a diesel engine) must be a continuous fuel oil flow, as defined above, in that any interruption in that flow will shut down the main engines of the ship, thereby rendering the ship incapable of maneuvering. As such, there cannot be any shutdown of the flow, even to clean a fuel oil filter located therein. To meet this requirement, the self cleaning fuel

oil strainer 20 provides the means for filtering such a continuous fuel oil flow without interrupting that flow, as will be discussed below in detail.

As shown more clearly in Fig. 2, the fuel oil strainer 20 comprises two canisters 26 and 28 that are fed fuel oil from a common input manifold 30 (e.g., 2½ inch class 150 ANSI flanged input) at the top portion of the strainer 20. Each canister 26 and 28 has two inputs from the common manifold 30, as indicated by inputs 32A and 32B for canister 26 and by inputs 34A and 34B for canister 28. Each canister 26 and 28 comprises a cylindrical-shaped porous member 36 and 38, respectively, through which the fuel oil flows, as will be discussed in detail later. The porous members 36 and 38 comprise a screen selected from the group consisting of wedge wire, wire cloth and perforated metal. In the preferred embodiment, the porous members 36 and 38 comprise wedge wire screens, such as those manufactured by Leem Filtration Products, Inc. of Mahwah, New Jersey. It is also within the broadest scope of the present invention that the porous members 36 and 38 may comprise wire cloth or perforated metal, as opposed to wedge wire screens. One of the main features of the oil strainer 20 is its ability to filter out fine particulate matter, e.g., particulates less than 100 microns, where a large percentage of these are less than 25 microns.

Drive mechanisms 40 and 42 (Fig. 3) are provided to rotate the respective porous members 36 and 38 during the cleaning process about their respective center axes, only one (44) of which is clearly shown in Fig. 5. Otherwise, during normal operation, the porous members 36 and 38 remain stationary.

As can be seen in Fig. 2, fuel oil enters each canister through its respective inputs and then flows around the periphery of each porous member 36 and 38; in particular, fuel oil flow from inputs 32A and 32B are shown by arrows 46A and 46B, respectively, and fuel oil flow from inputs 34A and 34B are shown by arrows 48A and 48B, respectively. The inputs 32A and 32B are located on both sides of an internal particulate chamber 50 (Fig. 7, which comprises two dislodge subchambers 50A/50B and a drain subchamber 50C, all of which are discussed later) in canister 26; similarly, although not shown, the inputs 34A and 34B in canister 28 are also located on both sides of a internal particulate chamber, also comprising two dislodge subchambers and a drain subchamber. Thus, fuel oil input flow moves away from the chamber 50 and

around the periphery of the porous members 36 and 38 and then through them, as is discussed next.

Fuel oil flow through the porous member is more easily depicted in Fig. 5, which is a cross-sectional view of the canister 26, although it should be understood that the following discussion is applicable to the other canister 28. The main fuel oil flow is through the porous member 36, from an outside surface 37 to an inside surface 39, as indicated by the arrows 52, and down through the hollow interior 41 of the porous member 36. As the fuel oil then flows through the porous member 36, particulate contaminants are then trapped against the outer surface 37 of the porous member 36. The filtered fuel oil exits into a main output 54 of the canister, as shown by the arrow 56. Fig. 4 is a bottom view of both canisters 26 and 28 and it shows the main output 54 of canister 26 and a main output 58 of canister 28 feeding into a common output manifold 60. Thus, fuel oil flow through the strainer 20 is basically continuous.

When cleaning of the porous member 36 and 38 is required, as indicated by pressure drop across the strainer 20 (as measured by a pressure transducer, not shown), the drive mechanisms 40 and 42 are activated to rotate the respective porous members. In addition, solenoid valves 72 and 74 (Fig. 3) are activated to open respective drains (only one 76 of which is shown in Fig. 5), located directly below the drain subchamber 50C, for diverting the particulate debris and a limited amount fuel oil down through a respective drain, rather than through the main outlets 54 and 58. Furthermore, it is within the broadest scope of this invention to include other alternative locations for the drain, e.g., along the chamber, rather than under it, as will be discussed in detail later. Opening of the drain 76 (or the alternative drain) is kept to a minimum to discard as little fuel as possible while flushing the particulate contaminants from the chamber. Thus, for example, the drain 76 can be open all or any part of the time that the porous members 36 and 38 are rotating.

Cleaning of the porous members 36 and 38 is accomplished by the particulate-removing means, only one of which is shown most clearly in Figs. 5, 7, 8 and 9; as such, the following discussion applies to the particulate-removal means in the canister 28 also. In the preferred embodiment, the particulate-removing means comprises an elongated wire brush 62 that spans the length of the porous member 36.

The brush fibers are in contact with the outside surface 37 of the porous screen 36 and thus bear on the outside surface 37 of the porous member 36 along its entire length. The brush 62 forms the separation between the two dislodge subchambers 50A and 50B, while the majority of a brush support 63 is disposed inside the drain subchamber 50C, as shown in Fig. 7.

As mentioned previously, the chamber 50 comprises the two dislodge subchambers 50A/50B and a drain subchamber 50C. The chamber 50 comprises a pair of confining walls 64A and 64B, also running the length of the porous member 36, that enclose the brush 62/brush support 63. The purpose of these walls 64A and 64B is to contain the dislodged particulate debris within the chamber 50 so that substantially only fuel oil within this chamber 50 will be discharged through the drain 76 (or alternative drain 300, to be discussed later) during cleaning. A partition 200, also running the length of the porous member 36, forms the separation between the two dislodge subchambers 50A/50B and the drain subchamber 50C. The partition 200 itself comprises a pair of outer flanges 202A/202B, a base wall 204 and sidewalls 206A/206B. The base wall 204 is secured between a particulate-removing means (e.g., brush 62 or scraper) head 61 and the particulate-removing means support 63. At the bend between the sidewalls 206A/206B and the outer flanges 202A/202B, the partition 200 comprises a plurality of apertures 212 (Figs. 7, 9, 11 and 12) that permit the passage of dislodged particulate contaminants from the two dislodge subchambers 50A/50B to the drain subchamber 50C. Because of the size of the apertures 212 (e.g., 0.094" diameter), once any particulate contaminants from the two dislodge subchambers 50A/50B make their way through the partition 200, there is very little chance that such particulate contaminants can find their way back through the apertures 212 and ultimately return to the outer surface 37.

A drain passageway 75, through a strainer support housing 77, is also shown in Figs. 5. Figs. 7 and 9 also show the passageway 75 in phantom.

At the extreme ends of the confining walls 64A and 64B, respective wipers 65A and 65B are secured to the outside surfaces of the walls 64A and 64B, respectively, and which also run the length of the porous member 36. The wipers 65A and 65B (e.g., 316 stainless steel, half-hard) are coupled to the ends of the walls 64A and 64B using fasteners 78 and plates 79. As can be seen most clearly in Fig. 13,

wiper 65A comprises a plurality of spaced-apart shoes or runners 67 that are in contact with the outer surface 37 of the porous member 36. These shoes 67 (e.g., 0.010" - 0.015" thickness and 1/4" wide and which may be spot-welded to the wiper 65A) serve to maintain the wiper 65A a sufficient distance away from the outer surface 37 such that during cleaning, while the porous member 36 is rotating (direction of rotation is shown by the arrow 161 in Fig. 7), the particulate contaminants adhering to the outer surface 37 pass beneath the wiper 65A between the shoes and then are driven off of the outer surface 37 by the particulate-removing means 62 and into the dislodge subchamber 50A. The drain subchamber 50C is in direct fluid communication with the drain 76 (or alternative drain 300). When the drain 76 (or alternative drain 300) is open, any particulate contaminants suspended in the dislodge subchamber 50A are pulled toward the apertures 212 in the partition 200 and pass through them and out to the drain 76 (or 300).

Any remaining particulate contaminants which cannot be mechanically driven off of the surface 37 by the brush 62, e.g., particulate contaminants lodged in between the outer surface 37 and the inside surface 39 of the porous member 36 (e.g., lodged in the wedge wire cells of a porous member 36 comprising wedge wire), are subjected to a reverse pressure and are driven out of the surface 37 into the second dislodge subchamber 50B. In particular, unlike the first dislodge subchamber 50A which is not totally closed off since the wiper 65A stands off from the outside surface 37 of the porous member 36, the second dislodge subchamber 50B forms a completely-closed off chamber because the wiper 65B does not include shoes and, therefore, is in contact with the outer surface 37 along its entire length. Thus, the second dislodge subchamber 50B is subjected completely to the influence of the pressure differential created between the inside surface 39 of the porous member 36 and the opened drain pressure which is present in the drain subchamber 50C, via the apertures 212. When the drain 76 (or 300) is open, these particulate contaminants, lodged in between the outer surface 37 and the inside surface 39 of the porous member 36, are driven out of that region by the reverse pressure differential and then are suspended in the second dislodge subchamber 50B; this pressure differential also pulls these particulate contaminants toward the apertures 212 in the partition 200 and into the drain subchamber 50C for passage through the drain 76 (or 300).

As pointed out earlier, the particulate contaminants are of an extremely small size, less than 100 microns, and a large percentage of these are less than 25 microns; as a result, these particulate contaminants do not settle out by gravity into the drain but rather, due to their small size, remain suspended in the fuel oil. The invention of the present application is well suited to overcome this problem as described below.

It should be understood that the apertures 212 provide for fluid communication between the first dislodge subchamber 50A and the drain subchamber 50C and for fluid communication between the second dislodge subchamber 50B and the drain subchamber 50C. However, because the apertures 212 are small, they maintain a high velocity of particulate contaminants from both the first and second dislodge subchambers 50A and 50B into the drain subchamber 50C under the influence of the reverse pressure differential. Such a high velocity cannot be sustained by replacing the apertures 212 with a slot. Furthermore, replacing the apertures 212 with a slot would defeat the purpose of maintaining the transferred particulate contaminants (i.e., particulate contaminants that have passed from the dislodge subchambers 50A/50B) in the drain chamber 50B since the particulate contaminants would not be precluded from making their way back to the outer surface 37 of the porous member 36.

In particular, the advantage of using the plurality of apertures, as opposed to a slot of the type shown in U.S. Patent No. 5,595,655 (Steiner et al.), is that the plurality of apertures provides for a rapid flow velocity as opposed to a low flow velocity for the slot. For example, if there are 21 apertures that form one set of apertures in the partition 200, each having a diameter of approximately 0.094", then the total area is approximately $\pi (0.094"/2)^2 \times 21 = 0.1457 \text{ in}^2$. If, on the other hand, a slot having a width of 0.094" and a length of 12.594" (i.e., the length from the top of the uppermost aperture in the partition 200 to the bottom-most aperture in the partition 200; this is a reasonable assumption since the Steiner et al. patent states that the slot is substantially equal to the scraper length-Steiner et al. patent, col. 1, lines 61-62) is used, the area is 1.184 in². Thus, using a plurality of apertures presents only 1/8 the area of the slot. As a result, for a given flow rate (gallons/minute), the slot may provide flow velocity of 1 ft/sec for a given drain flow, whereas the apertured partition generates a flow velocity of 8 ft/sec for a given drain flow. The higher velocity

significantly reduces the chance that a particulate will migrate backwards through the plurality of apertures and re-attach to the porous surface 36.

It is also within the broadest scope of the present invention to include an alternative drain 300 configuration as shown most clearly in Figs. 5, 8 and 12. To that end, a drain 300 is depicted along side the drain subchamber 50C rather than disposed underneath the subchamber 50C, as discussed previously. The drain 300 comprises drain passageways 302, 304 and 306 that form a portion of the particulate-removing means support 63. The passageways 302-306 are coupled at one end to a common manifold 308 through which the dislodged particulate contaminants are disposed of. As shown in Fig. 12, the other end of each passageway 302-306 comprises a respective cross hole 310, 312, and 314 disposed in the drain subchamber 50B. Thus, when a drain solenoid valve 316 (Fig. 5) is activated as discussed previously, particulate matter that has been dislodged from the outer surface 37 of the porous members 36/38 into the two dislodge subchambers 50A/50B, passes through the apertures 212 in the partition 200 into the drain chamber 50B. From there, the dislodged particulate contaminants are driven into the cross holes 310-314, through the passageways 302-306 and then into the common manifold 308. Thus, particulate contaminants dislodged from the outer surface 37 of the porous members 36/38 would be driven into the alternative drain 300.

Alternatively, instead of using a single solenoid valve 316, it is within the broadest scope of this invention to include dedicated solenoid valves 318, 320 and 322 (Fig. 5) that individually couple respective passageways 302-306 to the common manifold 308.

It is also within the broadest scope of the present invention that the term particulate-removing means include a brush, a scraper, or any equivalent device that is used to dislodge particulate contaminants from the outside surface 37 of the porous members 36 and 38. For example, where larger particulate contaminants are to be filtered from the fuel oil flow, a scraper (not shown) can be used in place of the brush 62.

As shown in Fig. 1, the oil strainer 20 can also be used in the fuel oil transfer subsystem portion of the compensated fuel oil system, with a few modifications. For example, the input 31 and the output 61 of the oil strainer 20 used

in the fuel oil transfer subsystem would be greater in size (as compared to the input 30 and output 60 of the oil strainer 20 used in the fuel oil service system discussed previously) to accommodate the larger fuel flow in that subsystem. In addition, the porous members 36 and 38 may need to only filter out particulate matter as small as 25 microns. In all other aspects, the oil strainer 20 used in the fuel oil transfer subsystem is similar to the oil strainer 20 used in the fuel oil service system. (The fuel oil transfer subsystem comprises the main fuel storage tank 22 in which sea water is used to replace fuel used).

It is also within the broadest scope of the present invention that the particulate-removing means also encompasses a reverse flow of clean fuel oil for dislodging the particulate contaminants from the fuel oil filter; or a reverse flow of clean fuel oil in combination with the particulate-removing member (e.g., brush or scraper), discussed previously.

In particular, as shown in Figs. 8-10, a second embodiment of the present invention comprises a particulate-removing means that includes an elongated spraying element 151 comprising a plurality of ports 153. The elongated spraying element 151 is coupled to a pressure source 155 (e.g., a pump, air supply, etc.) that recirculates clean fuel oil (whose flow is indicated by the arrow 56) into the elongated spraying element 151, during cleaning only, to create a high energy fuel oil spray that emanates from each of the ports 153. As shown most clearly in Fig. 9, the direction of the high energy spray (indicated by the arrow 157) is from the inside surface 39 to the outside surface 37 of the porous member 136. Thus, as the porous member 36 is rotated (direction indicated by the arrow 161) during cleaning, the high energy spray drives the particulate contaminants from the outside surface 39 into the dislodge subchamber 50B.

It should be understood that the particulate-removing means may comprise the elongated spraying element 151 alone for driving off the particulate contaminants, or the particulate-removing means may comprise a particulate-removing member (e.g., a brush 62 or scraper) in addition to the elongated spraying element 151, as shown in Figs. 8-9. Together, the elongated spraying element 151 and the particulate-removing member (e.g., brush 62 or scraper) act to dislodge the particulate contaminants from the outside surface 37 of the porous member 36 during cleaning.

When the particulate-removing member (e.g., a brush 62 or scraper) is used in combination with the elongated spraying element 151, the direction of the high energy spray (indicated by the arrow 163) may be set to occur after the particulate-removing member dislodges some of the particulate contaminants (Fig. 10), thereby driving particulate contaminants into the second dislodge subchamber 50B.

The porous member 36, for use in this second embodiment, comprises an open lower end 137 (Fig. 8) to permit passage of the elongated spraying element 151 therethrough.

Another variation of the self-cleaning fuel oil filter that utilizes a reverse flow of clean fuel oil for cleaning purposes is depicted at 220 in Fig. 14. In particular, as indicated by the arrow 165, during normal operation, contaminated fuel oil enters through an inlet valve 167 to a fuel oil filter 220. During normal operation, a drain valve 171 and a purge valve 173 remain closed, as will be discussed in detail later. The fuel oil filter 220 comprises a porous member 236, preferably having a wire cloth configuration. The direction of the fuel oil flow through the porous member 236 is given by the arrows 52 and is similar to the flow for the porous members discussed previously, i.e., from an outside surface 37 of the porous member 236 to an inside surface (not shown) of the porous member 236 and then through the center portion 41 of the porous member 236. The cleaned fuel oil is then passed through an outlet valve 175 in the direction of the arrow 177.

The cleaning process for the fuel oil filter 220 is different from the previous embodiments in that the porous member 236 does not move during cleaning. Instead, a reverse flow of clean fuel oil (the direction of this reverse flow is given by the arrow 179) is injected down through the center of the porous member 236, from the inside surface to the outside surface 37 of the porous member 236. This reverse flow of clean fuel oil impacts the entire inside surface of the porous member 236 and flows to the outside surface 37 of the porous member 236, thereby dislodging the particulate contaminants from the outside surface 37 of the porous member 236. Since this reverse flow acts through the entire porous member 236, there are no confining walls used. Thus, in this embodiment, the particulate removal means comprises only the reverse flow of clean fuel oil. Because this reverse flow of clean fuel oil is applied

through the entire porous member 236, the fuel oil filter 220 must be isolated from the normal fuel oil flow during cleaning, as will be discussed in detail below.

In particular, when cleaning is required, the inlet valve 167 and outlet valve 175 are closed and the purge valve 173 and drain valve 171 are opened. The purge valve 173 is coupled to a clean fuel reservoir 181 which is under pressure (e.g., an air supply, whose input flow is indicated by the arrow 183 and having a valve 185 for maintaining air pressure in the reservoir 181. The downstream clean fuel, indicated by the arrow 187, enters the reservoir 181 through a recharge valve 189). When the purge valve 173 is opened, the reverse flow of clean fuel oil 179 drives the particulate contaminants off of the outside surface 37 of the porous member 236. Since the drain valve 171 is also opened, the reverse flow, now containing the dislodged particulate contaminants, flows out, as indicated by the arrow 191, through the drain valve 171. Once this flow of dislodged particulate contaminants passes to the drain, the purge valve 173 and the drain valve 171 are closed and the input valve 167 and the output valve 175 are opened, restoring normal fuel oil flow.

It should be understood that the continuous fuel oil flow is accomplished by having a plurality (e.g., five to eight) parallel, non-rotating filter paths (not shown) that are coupled to the reservoir 181 through respective purge valves 173. Thus, when any one non-rotation filter path is being cleaned using the reverse fuel oil flow, the remaining parallel channels are operating under the normal fuel oil flow.

Another variation of this embodiment, depicted in Fig. 15, uses the downstream clean fuel oil directly to create the reverse fuel oil flow. In particular, the purge valve 173 is coupled directly to the downstream clean fuel oil flow. The sequence of valve openings/closings are similar to that described previously. Thus, when the purge valve 173 and the drain valve 171 are opened, the reverse flow of clean fuel oil, the direction indicated by the arrow 179, is generated directly from the downstream clean fuel oil flow.

Another variation of this embodiment is shown in Fig. 16 that uses passive components such as a check valve 400 and a flow restricting orifice 402 in place of the purge valve 173.

It should also be understood that the variations of Figs. 15 and 16, like that discussed with regard to Fig. 14, also comprise a plurality of parallel, non-rotating

filter paths that permit the continuous flow of fuel oil when any one of the parallel, non-rotating filter paths is being cleaned by the reverse flow of clean fuel oil.

Without further elaboration, the foregoing will so fully illustrate our invention and others may, by applying current or future knowledge, readily adapt the same for use under various conditions of service.

CLAIMS

1. A fuel oil cleaning device disposed within a continuous fuel oil flow having particulate contaminants therein, said cleaning device comprising:

a porous member in fluid communication with the fuel oil flow such that the fuel oil flow enters said porous member through a first porous member surface and exits through a second porous member surface, said fuel oil flow depositing the particulate contaminants on said first porous member surface;

particulate-removing means disposed to be in close proximity with said porous member for removing particulate contaminants from said first porous member surface along substantially the entirety of the length of said first porous member surface;

a pair of flow confining walls disposed to be in close proximity with said first porous member surface along substantially the entirety of the length of said first porous member surface for defining a chamber;

a partition dividing said chamber into a first subchamber and a second subchamber along the length of said chamber;

a drive mechanism for displacing said porous member for continuously directing particulate contaminants deposited on said first porous surface past the particulate removing means for continuously dislodging the particulate contaminants from said first porous member surface into said first subchamber;

said partition including first and second portions on opposite sides of said particulate removing means and each portion having a plurality of apertures for passing the dislodged particulate contaminants from said first subchamber into said second subchamber; and

a drain being in communication with said second subchamber and through which the dislodged particulate contaminants are removed when said drain is opened.

2. The fuel oil cleaning device of Claim 1 wherein when said drain is opened a drain flow is created and wherein said plurality of apertures are of sufficient area to generate a rapid velocity of dislodged particulates from said first subchamber into said second subchamber.

3. The fuel oil cleaning device of Claim 2 wherein said plurality of apertures are linearly arranged to define an effective aperture length and wherein each aperture comprises a diameter, said rapid velocity of dislodged particulate contaminants being approximately eight times a velocity of dislodged particulate contaminants established by a slot having said effective aperture length and a width comprising said diameter for a given drain flow.

4. The fuel oil cleaning device of Claim 1 wherein said particulate removing means comprises a brush or scraper closely adjacent said first porous member surface and wherein said first subchamber is divided into a first dislodge subchamber and a second dislodge subchamber by said particulate-removing means and wherein:

 said first dislodge chamber is formed between said first porous member surface, one of said confining walls, said brush or scraper, said partition and a first flexible member disposed between said one of said confining walls and said first porous member surface; and

 said second dislodge chamber is formed between said first porous member surface, the other of said confining walls, said brush or scraper, said partition and a second flexible member that is disposed between said other of said confining walls and said first porous member surface.

5. The fuel oil cleaning device of Claim 4 where said first flexible member comprises a plurality of shoes that are in contact with said first porous member surface for disposing said first flexible member closely adjacent said first porous member surface.

6. The fuel oil cleaning device of Claim 4 wherein said first flexible member is disposed away from said first porous member surface in the range of 0.010 inches to 0.015 inches.

7. The fuel oil cleaning device of Claim 1 wherein said particulate-removing means comprises a spraying element positioned closely adjacent said second porous member surface and opposite said pair of confining walls for generating a reverse flow of clean oil, said reverse flow being directed from said second porous member surface through said first porous member surface for dislodging the particulate contaminants away from said first porous member surface into said first subchamber.

8. The fuel oil cleaning device of Claim 7 wherein said spraying element comprises an elongated lumen comprising a plurality of ports and coupled to a pressure source to clean fuel oil.

9. The fuel oil cleaning device of Claim 1 wherein said particulate removing means comprises a brush or scraper and wherein said drain comprises:

a plurality of particulate-removing means supports that include respective internal passageways that are in fluid communication with said second subchamber;

a common manifold to which said respective internal passageways are coupled; and

a drain valve coupled to said common manifold for controlling the opening and closing of said drain.

10. The fuel oil cleaning device of Claim 1 wherein said particulate removing means comprises a brush or scraper and wherein said drain comprises:

a plurality of brush or scraper supports that include respective internal passageways that are in fluid communication with said second subchamber;

a respective passageway valve coupled to each passageway for controlling the passage of particulate contaminants through said respective passageway; and

a common manifold coupled to said respective passageway valves for conveying particulate contaminants out of said passageways.

11. The fuel oil cleaning device of Claim 1 wherein said porous member comprises a cylindrical-shaped filter and wherein said first porous member surface is the outer surface of said cylindrical-shaped filter and wherein said second porous member surface is the inner surface of said cylindrical-shaped filter.

12. The fuel oil cleaning device of Claim 11 wherein said drive mechanism displaces said filter by causing it to rotate.

13. The fuel oil cleaning device of Claim 12 wherein said confining walls comprise respective outer surfaces away from said member and wherein said fluid communication comprises a first input fuel oil flow and a second input fuel oil flow on a respective outer surface away from said member.

14. The fuel oil cleaning device of Claim 1 wherein said porous member traps particulate contaminants as small as approximately 25 microns.

15. The fuel oil cleaning device of Claim 14 wherein said porous member comprises a screen selected from the group consisting of wedge wire, wire cloth and perforated metal.

16. The fuel oil cleaning device of Claim 7 wherein said cylindrical-shaped filter screen comprises a screen selected from the group consisting of wedge wire, wire cloth and perforated metal.

17. The fuel oil cleaning device of Claim 16 wherein said cylindrical-shaped filter screen comprises a wedge wire configuration for trapping particulate contaminants.

18. The fuel oil cleaning device of Claim 17 wherein said cylindrical-shaped filter screen comprises a wedge wire configuration for trapping particulate contaminants as small as approximately 25 microns.

19. A fuel oil cleaning system for use with a fuel oil flow having particulate contaminants therein, said cleaning system comprising:

an inlet valve for controlling the fuel oil flow having particulate contaminants therein;

a porous member having an input coupled to said inlet valve, said porous member being in fluid communication with the fuel oil flow such that the fuel oil flow enters said porous member through a first porous member surface and exits through a second porous member surface, said fuel oil flow depositing the particulate contaminants on said first porous member surface, said fuel oil flow exiting through said second porous member surface defining a clean fuel oil flow that flows out of said porous member at an output;

an outlet valve coupled to said output for controlling said clean fuel oil flow;

a flow control means having a flow control means input coupled to a source of clean fuel oil and a flow control means output coupled to said output, said flow control means controlling a reverse flow of said clean fuel oil from said second porous member surface through said first porous member surface for dislodging the particulate contaminants from

said first porous member surface to form a contaminated reverse flow of fuel oil;

a drain valve coupled to said input for directing said contaminated reverse flow of fuel oil; and

said inlet valve and outlet valve being closed during cleaning and said flow control means and said drain valve being opened during cleaning.

20. The fuel oil cleaning system of Claim 19 wherein said source of clean fuel oil is a pressurized fuel oil reservoir.

21. The fuel oil cleaning system of Claim 19 wherein said source of clean fuel oil is clean fuel oil that has passed thorough said outlet valve.

22. The fuel oil cleaning system of Claim 19 wherein said porous member comprises a cylindrical-shaped filter and wherein said first porous member surface is the outer surface of said cylindrical-shaped filter and wherein said second porous member surface is the inner surface of said cylindrical-shaped filter.

23. The fuel oil cleaning system of Claim 22 wherein said cylindrical-shaped filter comprises a wire cloth configuration.

24. The fuel oil cleaning system of Claim 19 wherein said flow control means comprises a purge valve.

25. The fuel oil cleaning system of Claim 19 wherein said flow control means comprises a check valve and a flow restricting orifice.

26. A method for cleaning a fuel oil flow having particulate contaminants therein, said method comprising the steps of:

disposing a porous member in fluid communication with the fuel oil flow such that the fuel oil flow enters said porous member through a

first porous member surface and exits through a second porous member surface so that the fuel oil flow deposits the particulate contaminants on said first porous member surface;

positioning a pair of flow confining walls adjacent said first porous member surface to define a chamber and positioning a respective flexible member between a respective flow confining wall and said first porous surface member, said respective flexible members being in contact with said first porous surface;

positioning a particulate-removing means closely-adjacent said porous member;

dividing said chamber into first and second subchambers with a partition having first and second portions on opposite sides of said particulate removing means and each portion having a plurality of apertures to provide fluid communication between said first and second subchambers, said second subchamber being in fluid communication with a drain when the drain is opened;

displacing said porous member to permit said particulate-removing means to dislodge particulate contaminants trapped on said first porous member surface into said first subchamber; and

opening the drain to cause the dislodged particulate contaminants to pass through said plurality of apertures into said second subchamber and out into the drain.

27. The method of Claim 26 wherein one of said respective flexible members is positioned to be in contact with said first porous member surface at discrete locations.

28. The method of Claim 27 wherein said step of displacing said porous member comprises displacing said first porous member surface transversely

in front of said particulate-removing means in a first direction, said first porous member surface passing said one of said respective flexible members that is in contact with said first porous member surface at discrete locations before passing in front of said particulate-removing means.

29. The method of Claim 26 wherein said particulate removing means comprises a brush or scraper positioned closely adjacent said first porous member surface.

30. The method of Claim 26 wherein said particulate removing means comprises a spraying element positioned closely adjacent said second porous member surface opposite said pair of confining walls for generating a reverse flow of clean oil, said reverse flow being directed from said second porous member surface through said first porous member surface for dislodging the particulate contaminants away from said first porous surface into said first subchamber.

31. A method for cleaning a fuel oil flow having particulate contaminants therein, said method comprising the steps of:

disposing a porous member in fluid communication with the fuel oil flow such that the fuel oil flow enters said porous member through a first porous member surface and exits through a second porous member surface so that the fuel oil flow deposits the particulate contaminants on said first porous member surface;

isolating said porous member from the fuel oil flow;

sending a reverse flow of clean fuel oil through said porous member from said second porous surface member surface to said first porous member surface for dislodging the particulate contaminants from said first porous member surface to form a contaminated reverse flow of fuel oil;

opening a drain to receive said contaminated reverse flow of fuel oil; and

recoupling said porous member to the fuel oil flow.

32. The method of Claim 31 wherein said step of disposing said porous member in fluid communication with the fuel oil flow comprises positioning a cylindrical-shaped filter screen in the fuel oil flow such that said first porous member surface is the outer surface of said cylindrical-shaped filter screen and wherein said second porous member surface is the inner surface of said cylindrical-shaped filter screen.

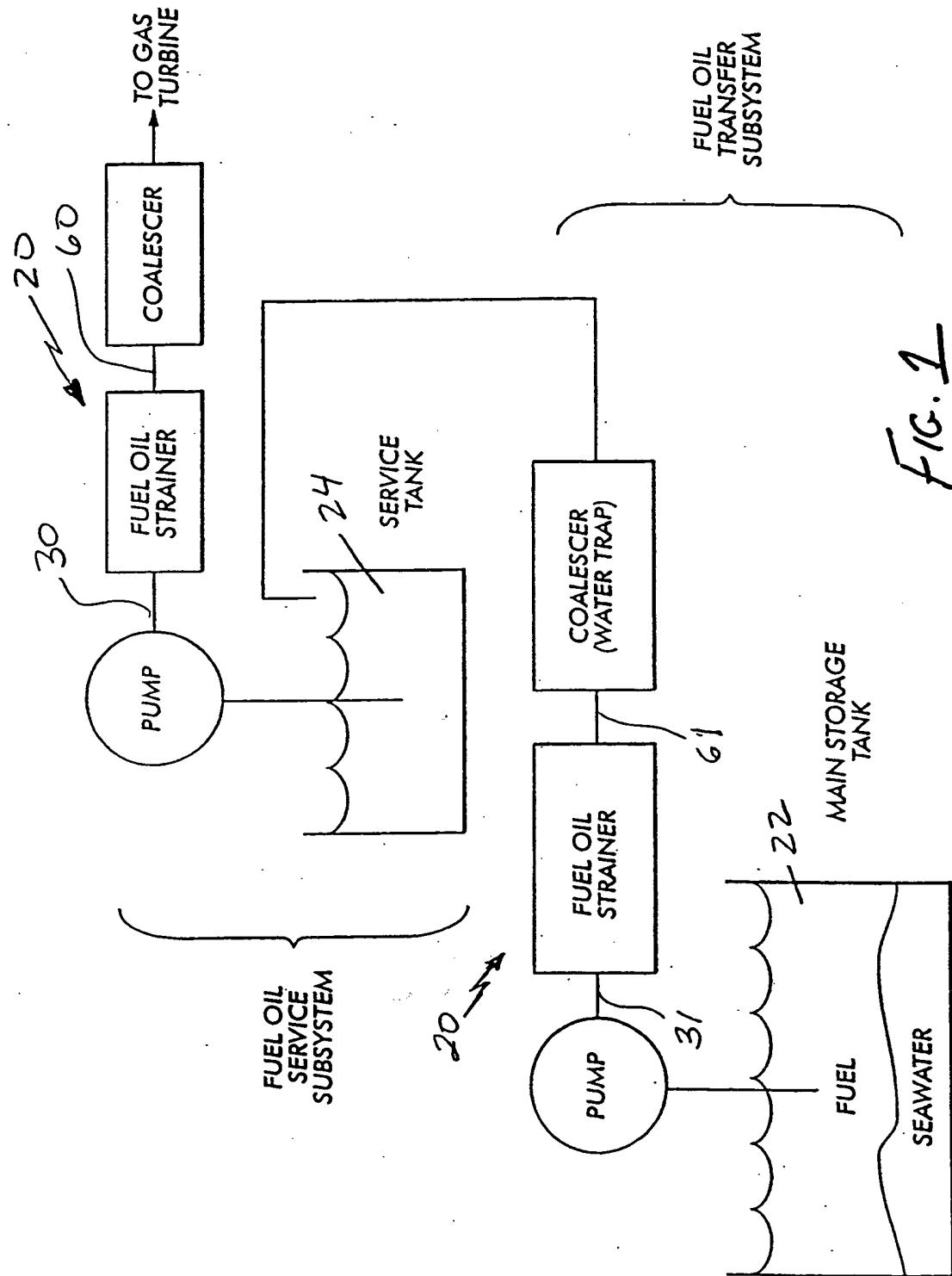


FIG. 1

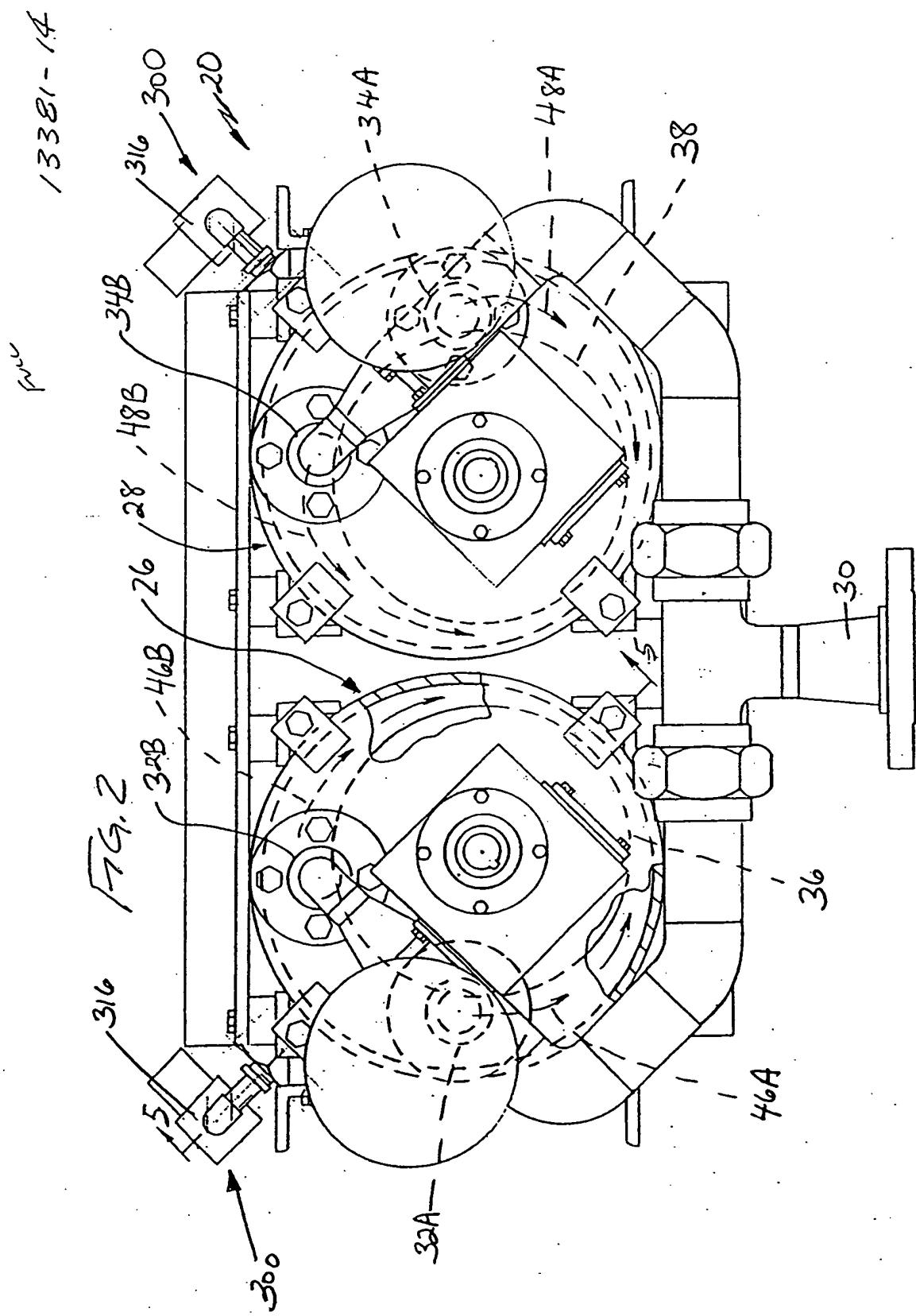
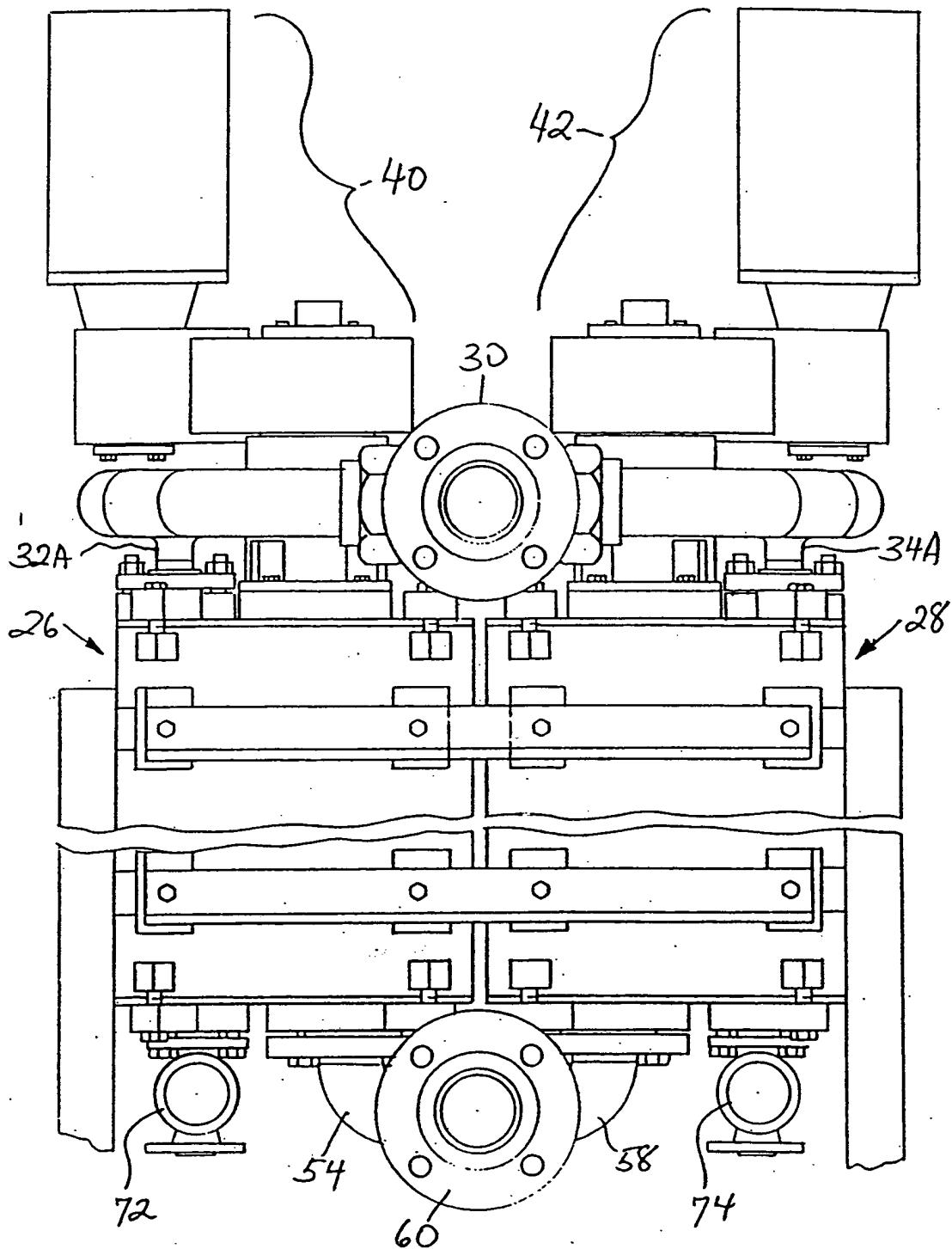


FIG. 3



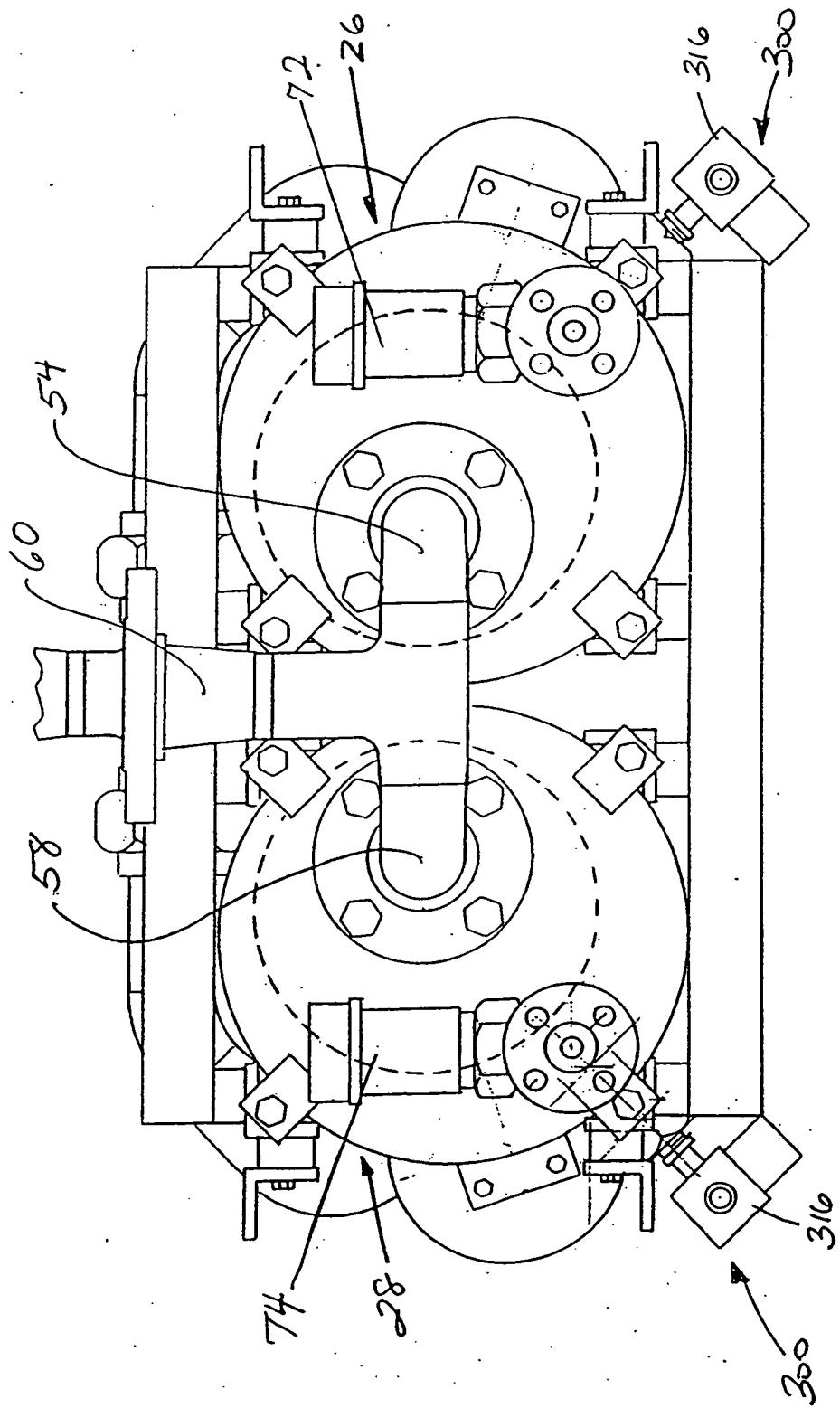


FIG 4

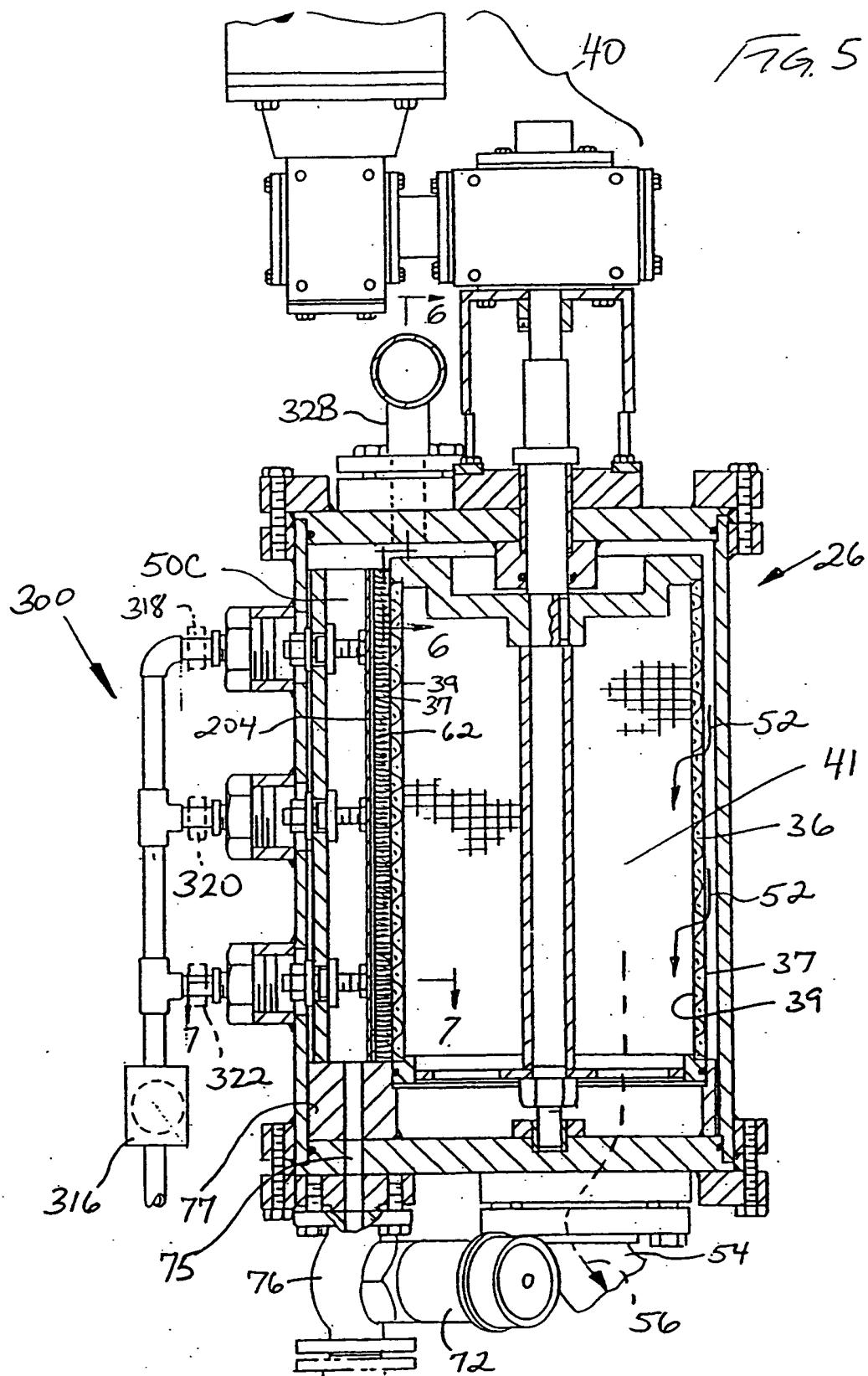


FIG. 6

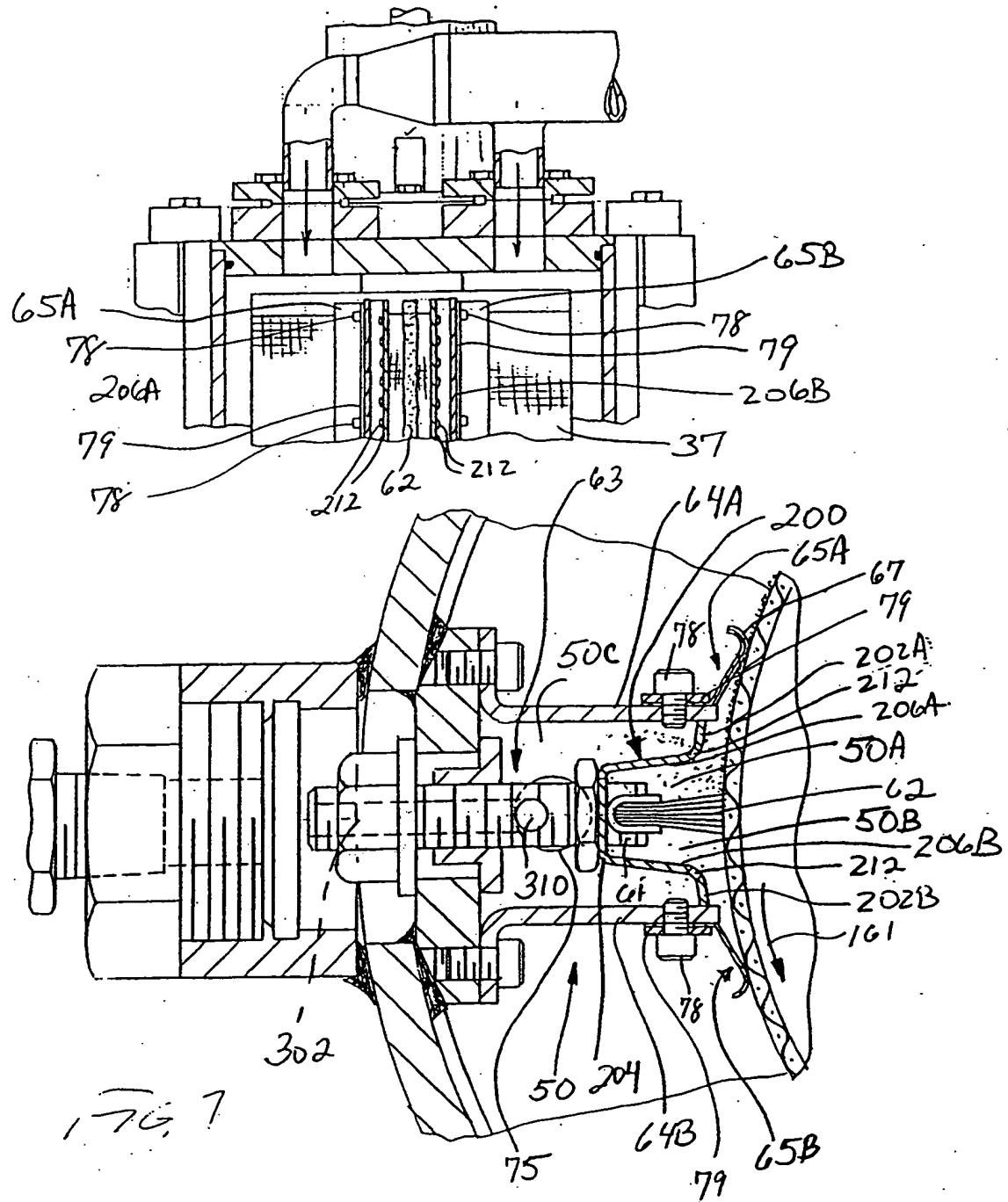


FIG. 7

FIG 8

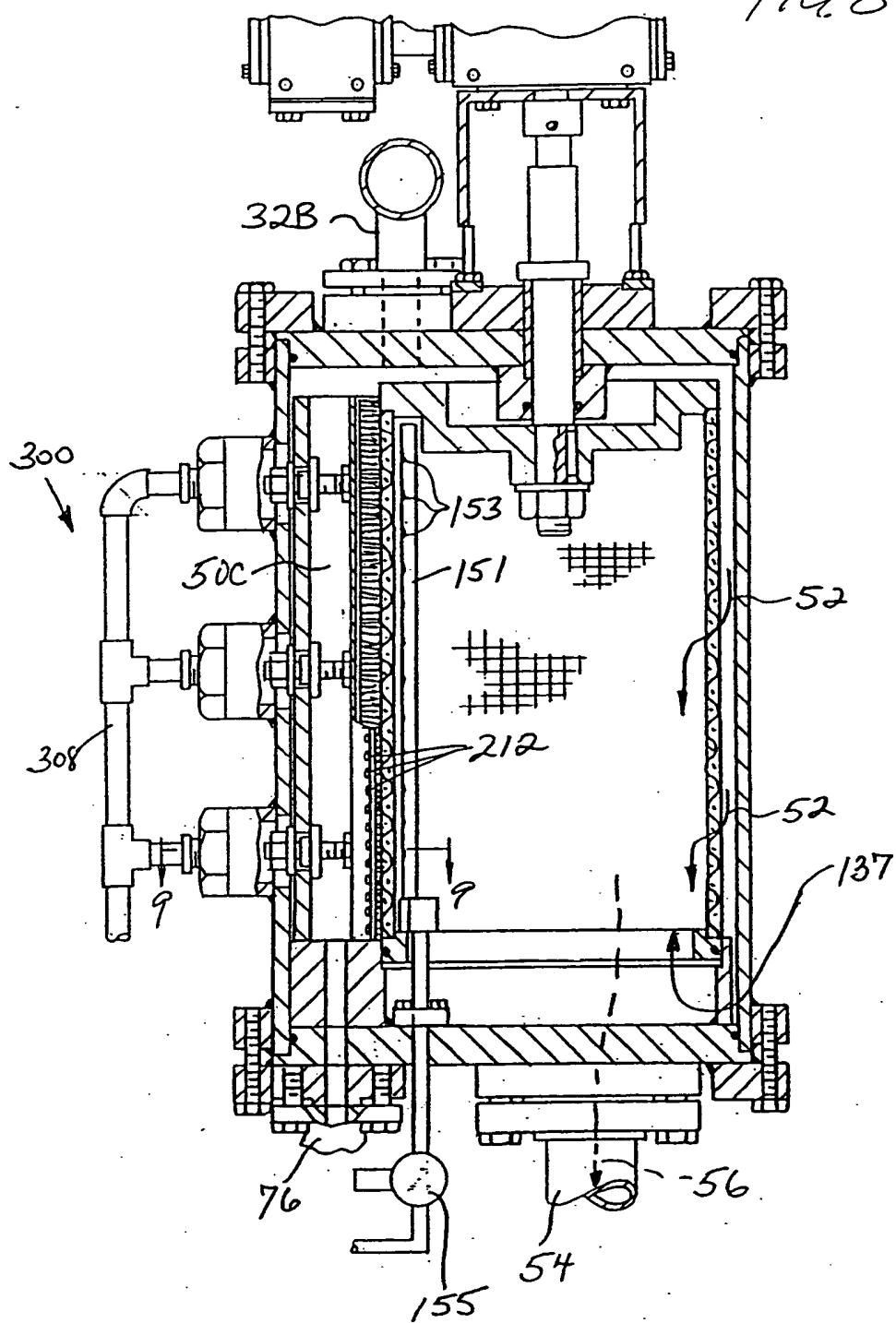


FIG. 9

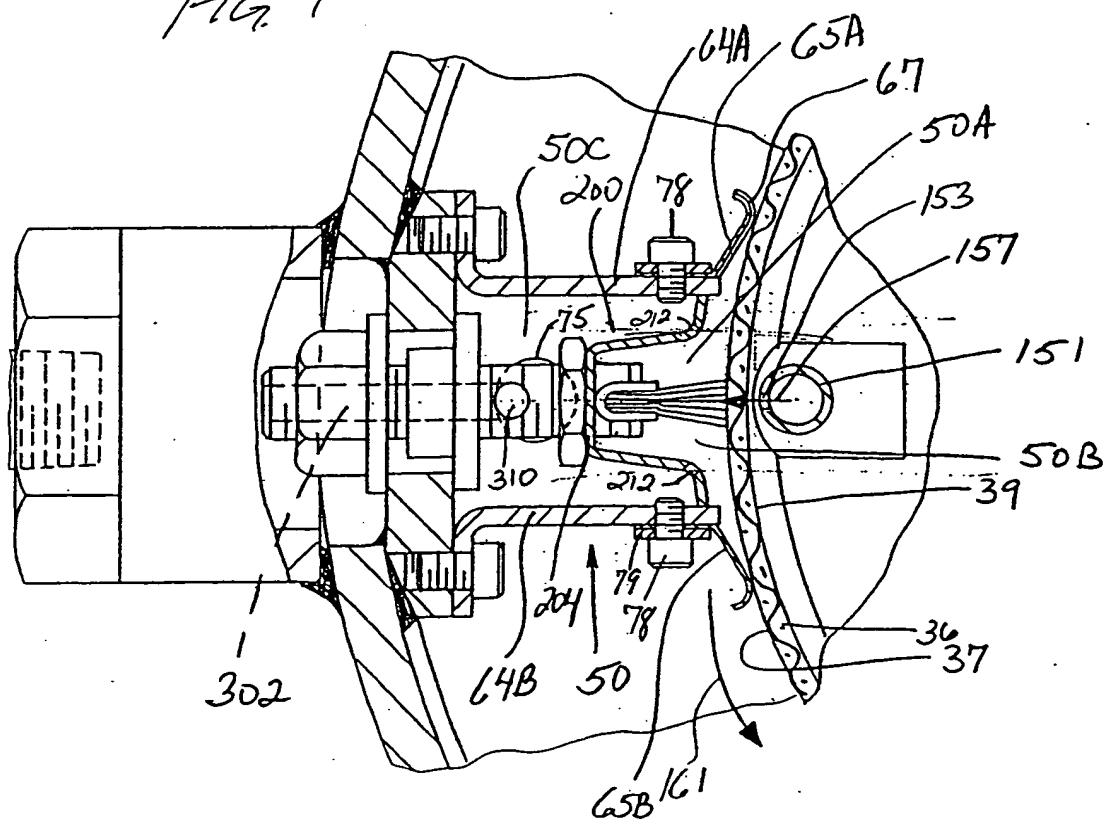


FIG. 10

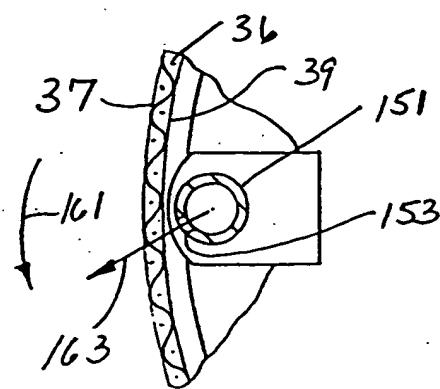


FIG. 11

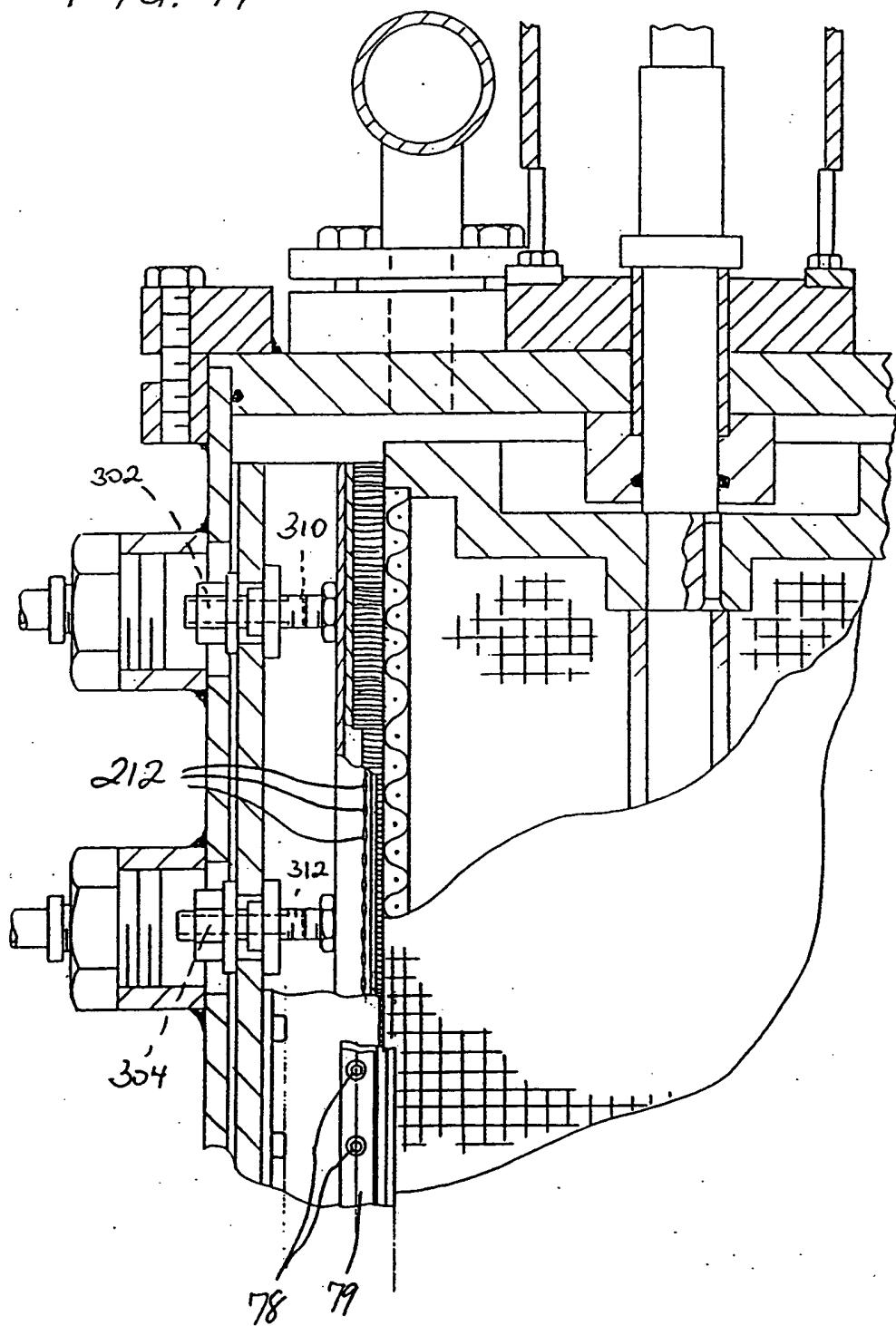
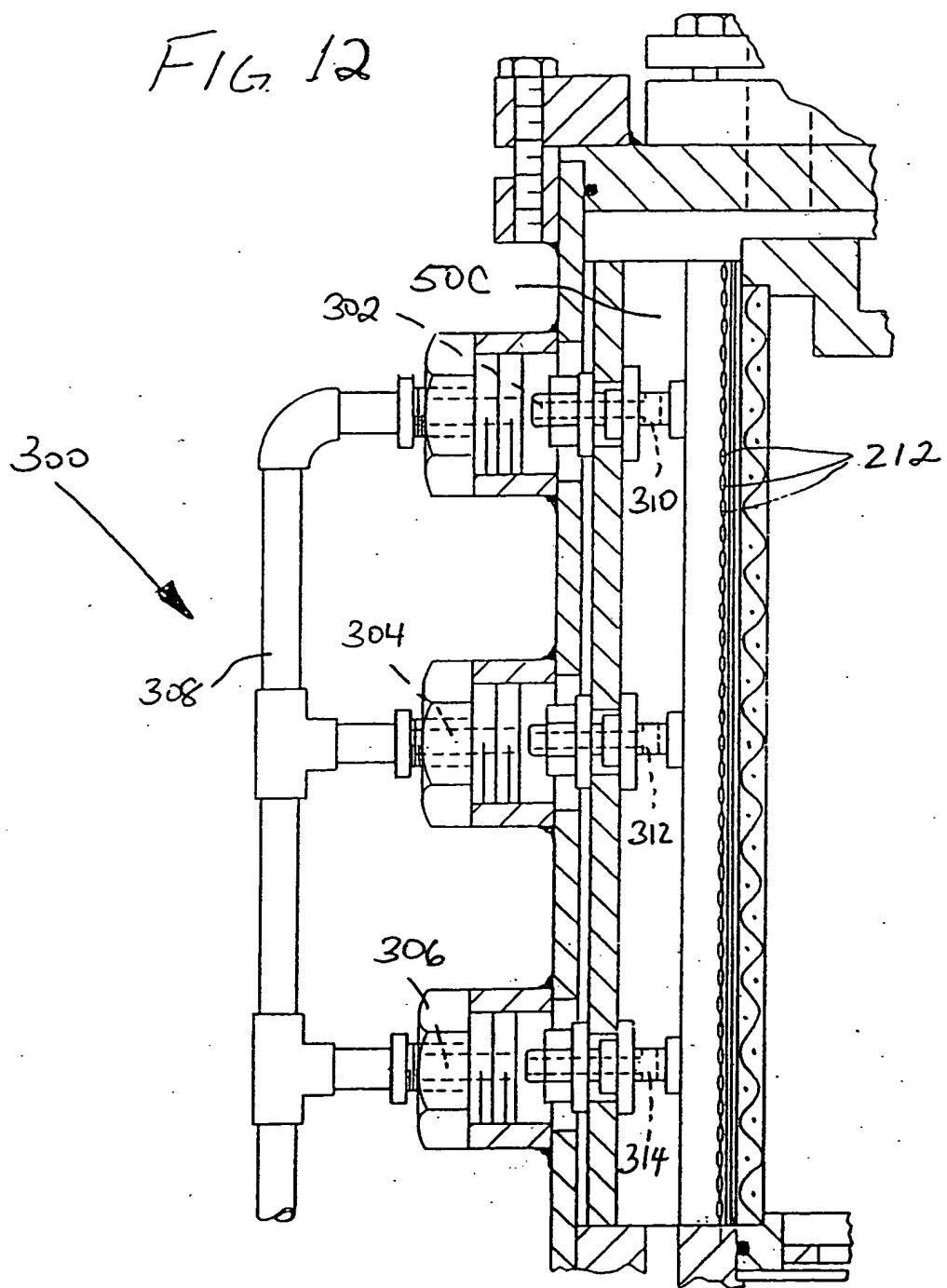


FIG. 12



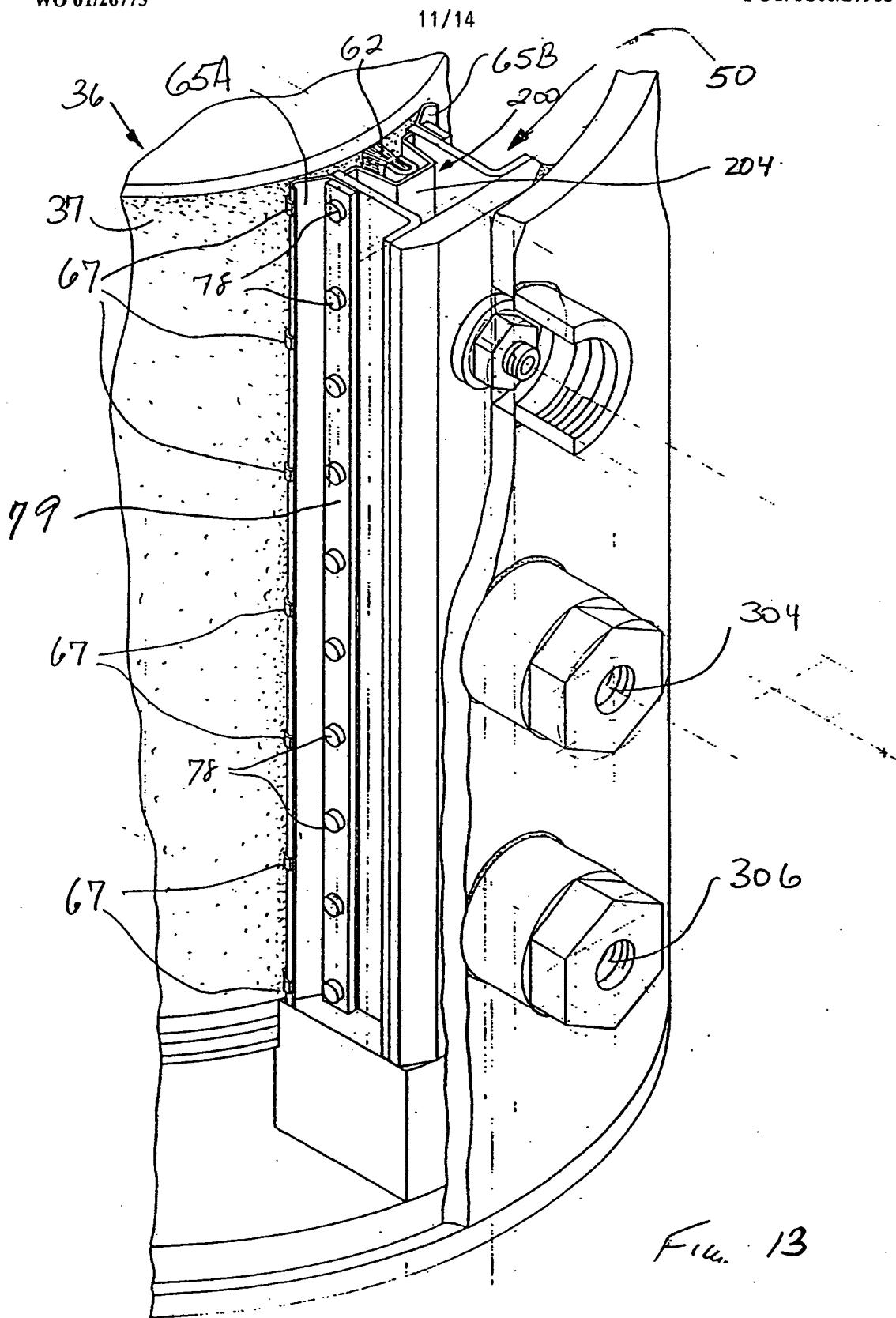
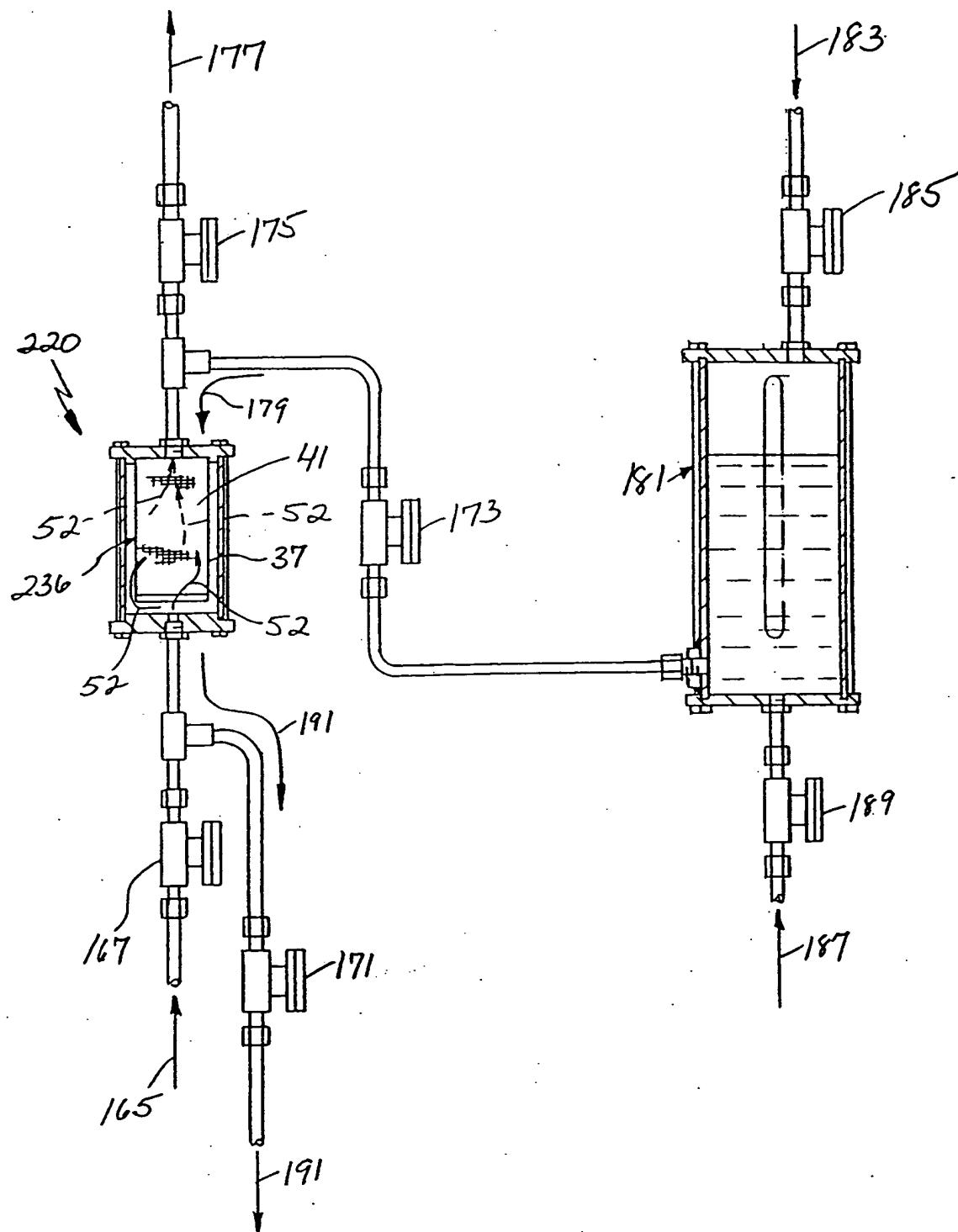


Fig. 13

FIG. 14



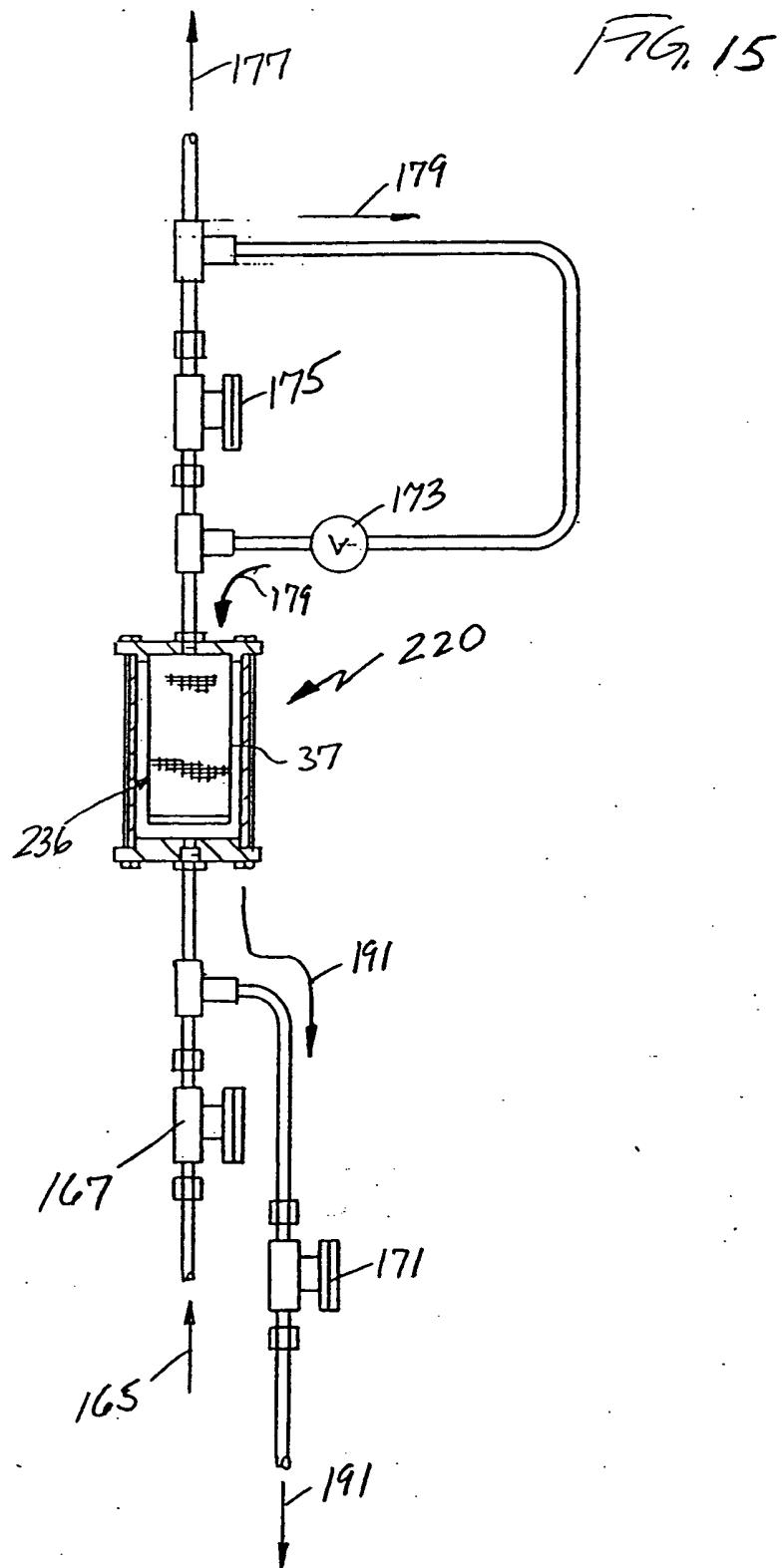
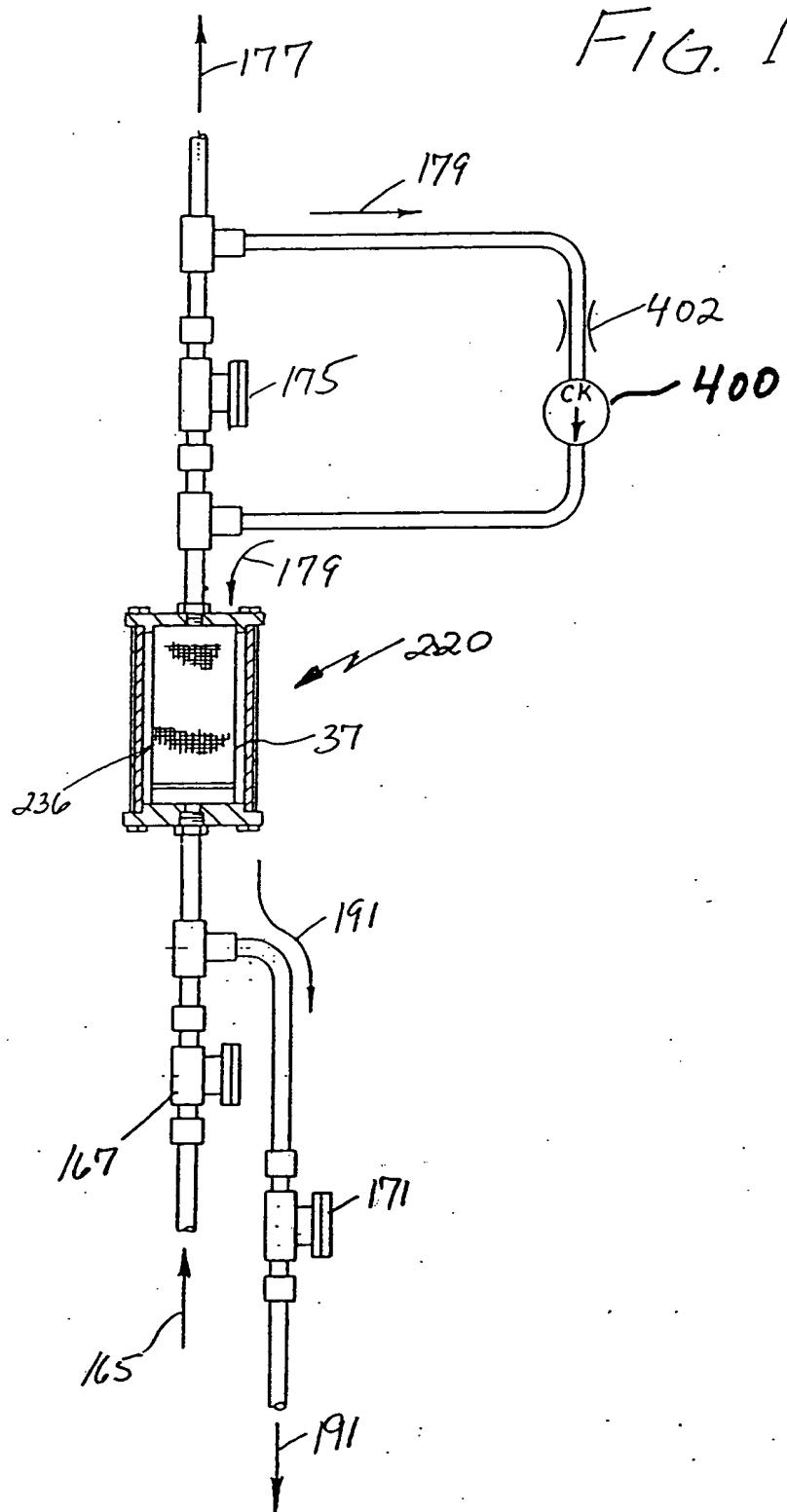


FIG. 16





CORRECTED VERSION

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(71) Applicants and
(72) Inventors: BENENSON, James, Jr. [US/US]; 1 Lexington Avenue, New York, NY 10010 (US). LAING, David, A. [US/US]; 217 Northfield Drive, Elyria, OH 44035 (US).

(74) Agent: SLOMOWITZ, Scott, M.; Caesar, Rivise, Bernstein, Cohen & Pokotilow, Ltd., Seven Penn Center, 12th floor, 1635 Market Street, Philadelphia, PA 19103-2212 (US).

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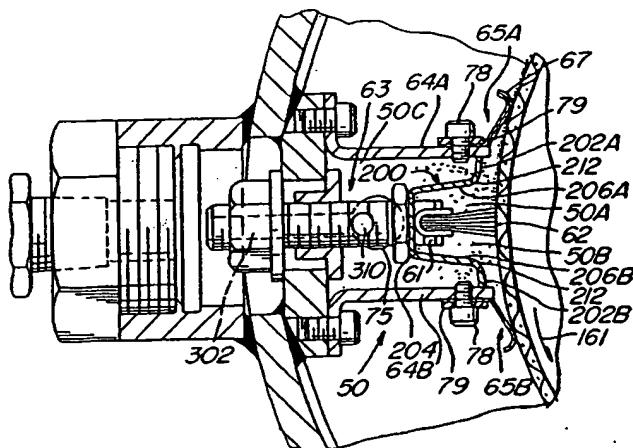
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(54) Title: SELF-CLEANING FUEL OIL STRAINER



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(57) Abstract: A self-cleaning fuel oil strainer, coupled to a continuous fuel flow, that includes a pair of canisters (26, 28), each having a cylindrical wedge wire fuel oil filter screen. An elongated brush (62) running the length of the screen is disposed between two confining walls also running the length of the screen to form a chamber. An elongated partition (200), including two sets of apertures (212), is used, along with the elongated brush, to divide the chamber into two particulate dislodge chambers and a drain subchamber. A drain is in fluid communication with the drain subchamber. During cleaning, the drain is opened and the screen is rotated against the brush for liberating the particulate contaminants and a limited amount of fuel oil into the two dislodge subchambers. The particulate contaminants and the limited amount of fuel oil then pass through the apertures at a high velocity and into the drain subchamber (50c) which exits through the drain. Alternatively, a reverse flow of clean fuel oil can be used in combination with the elongated brush, for dislodging the particulate contaminants from the fuel oil filter screen. Finally, another variation of using a reverse flow of clean fuel oil for cleaning purposes is discussed whereby a stationary fuel oil strainer is disposed in a system that isolates the fuel oil strainer from the normal fuel oil flow during cleaning.



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II

SELF-CLEANING FUEL OIL STRAINER

SPECIFICATION

BACKGROUND OF THE INVENTION

This invention relates generally to filter devices and, more particularly, to fuel system filters for small particulate contaminants.

It is well-known that the mechanical cleaning of a filter surface can be accomplished by having a brush or scraper drag along the filter surface where deposits have accumulated. In certain configurations, the brush or scraper is mounted at one end between two walls but with a significant portion of the brush or scraper projecting beyond the walls. Such configurations are shown in U.S. Patent Nos. 148,557 (Gillespie et al.); 556,725 (Farwell); 740,574 (Kohlmeyer) and 793,720 (Godbe). In conventional filter systems, the particulate contaminants are driven off the filter surface and are deposited in a hopper or tank along with the fluid being filtered, thus discarding large amounts of the fluid being filtered.

The use of a brush, or high speed cleaning spray, disposed between a pair of walls for cleaning a cylindrical filter is known in the art, as is disclosed in U.S. Patent Nos. 5,423,977 (Aoki et al.) and 5,595,655 (Steiner et al.) and Swiss Patent No. 22,863 (Zingg). Another variation employs a backwash that drives the particulate contaminants off of the cylindrical filter, as is disclosed in U.S. Patent No. 3,338,416 (Barry).

One desirable use for fuel oil filter systems of the present invention is in ships. Prior art ship fuel oil systems use conventional filter cartridges for cleaning the fuel in-line. However, these filter cartridges require frequent replacement which, in turn, requires the fuel flow to be interrupted during replacement. Interruption of the fuel oil flow will shut down the ship's main engines, thereby rendering the ship incapable of maneuvering. This can be catastrophic where the ship is in tight quarters, e.g., during docking or navigating through narrow passageways, or during storms, or during battle with regard to warships. Furthermore, there are additional costs of having to store sufficient replacement cartridges onboard, the logistics involved in shipping and disposing the cartridges to and from the ship, and the labor costs involved in replacing the cartridges.

In addition, shipboard fuel oil straining is a specialized straining process. In particular, the fuel oil flow is initially pre-strained for gross particulate contaminants, such that any particulate contaminants remaining in the fuel oil flow are extremely small (e.g., < 100 microns, with a large percentage being less than 25 microns). As a result, where these small particulate contaminants are captured by a downstream strainer (e.g., a wedge wire screen strainer), both on and within the strainer surface, and then later dislodged during the strainer cleaning process, these extremely small particulate contaminants do not fall by gravity toward a drain but remain suspended in the fuel oil and will re-attach to the strainer surface. Therefore, there remains a need for a cleaning device that can dislodge such extremely small particulate contaminants off of the downstream strainer surface, as well as from within the strainer surface, and then ensure that these particulate contaminants flow out through the drain rather than re-attaching to the strainer surface.

Thus, there is a need for an improved system for removing undesired particulate contaminants from a fuel oil flow and without interrupting that fuel oil flow to the engines, while minimizing the amount of fluid removed therewith. It is to just such a system that the present invention is directed.

OBJECTS OF THE INVENTION

Accordingly, it is the general object of the instant invention to provide a fuel oil cleaning device that overcomes the problems of the prior art.

It is a further object of this invention to provide a fuel oil cleaning device that permits continuous fuel oil flow even during the cleaning process.

It is a further object of this invention to provide a fuel oil cleaning device that removes small particulate contaminants from a strainer surface, and from within the strainer surface, and ensures that when these small particulate contaminants are dislodged from the strainer during cleaning that they enter a drain rather than re-attaching to the strainer surface.

It is still yet another object of this invention to provide a fuel oil cleaning device that generates a high velocity flow of dislodged particulate contaminants away from the strainer and into a drain.

It is a further object of this invention to provide a fuel oil cleaning device that minimizes the amount of fuel oil that must be discarded during cleaning.

It is still yet a further object of this invention to eliminate the need for frequent replacement of the fuel oil filter.

It is still another object of this invention to minimize the costs associated with frequent fuel oil filter replacements.

It is still yet even another object of this invention to improve the efficiency of particulate removal.

It is still yet another object of this invention to provide a fuel oil filter that can be self-cleaned with the use of a reverse flow of clean fuel oil.

It is even yet another object of this invention to provide a self-cleaning fuel oil filter system that permits the fuel oil filter element to remain stationary during cleaning.

SUMMARY OF THE INVENTION

These and other objects of the invention are achieved by providing a fuel oil cleaning device disposed within a continuous fuel oil flow having particulate contaminants therein. As mentioned earlier, the particulate contaminants that need to be removed from the fuel oil flow are extremely small, less than 100 microns, and a large percentage of these less than 25 microns, therefore do not settle out by gravity. The invention of the present application is well-suited to removing these small particulate contaminants from the fuel oil flow and into a drain. The cleaning device comprises a porous member in fluid communication with the fuel oil flow such that the fuel oil flow enters the porous member through a first porous member surface and exits through a second porous member surface and wherein the fuel oil flow deposits the particulate contaminants on the first porous member surface. The cleaning device further comprises particulate-removing means (e.g., a brush, a scraper, or equivalent device, or a reverse flow of clean fuel oil, or any combination of these for removing particulate contaminants from the porous member) disposed to be in close proximity with the first porous member surface for removing particulate contaminants from the first porous member surface along substantially the entirety of the length of the first porous member surface. The cleaning device also comprises a drive mechanism for displacing the porous member such that the particulate-removing means dislodges the particulate contaminants from the first porous member surface during the displacement. In addition, the cleaning device includes a pair of flow confining walls

disposed to be in close proximity with the first porous member surface along substantially the entirety of the length of the first porous member surface for defining a chamber for confining the removed particulate contaminants therein. The particulate-removing means is positioned within the chamber. The cleaning device also comprises a drain that is in communication with the chamber and through which the dislodged particulate contaminants are removed when the drain is opened. The cleaning device further comprises a partition that divides the chamber into a first subchamber and a second subchamber along the length of the chamber and wherein the drain is in communication with the second subchamber. The partition includes a plurality of apertures for passing the dislodged particulate contaminants from the first subchamber into the second subchamber. The plurality of apertures is of sufficient area to generate a rapid velocity of dislodged particulate contaminants from the first subchamber to the second subchamber.

The term continuous fuel oil flow is defined as a fuel oil flow that is uninterrupted, regardless of the fuel system cleaning function status.

Where the particulate-removing means is a mechanical means (e.g., a brush or scraper), it is functional within the confines of the pair of walls. Where the particulate-removing means comprises a reverse flow of clean fuel, the reverse flow is opposite the pair of confining walls and the reverse flow is directed from the second porous surface to the first porous surface.

The above invention also includes a method for cleaning a fuel oil flow having particulate contaminants therein. The method comprises the steps of: disposing a porous member in fluid communication with the fuel oil flow such that the fuel oil flow enters the porous member through a first porous member surface and exits through a second porous member surface so that the fuel oil flow deposits the particulate contaminants on the first porous member surface; positioning a pair of flow confining walls adjacent the first porous member surface to define a chamber; positioning a particulate-removing means within the chamber and closely-adjacent the first porous surface member; dividing the chamber into first and second subchambers with a partition wherein the particulate-removing means is disposed in the first subchamber and the second subchamber is in fluid communication with a drain when the drain is opened; providing a plurality of apertures in the partition to provide fluid communication

between the first and second subchambers; and displacing the porous member to permit the particulate-removing means to dislodge particulate contaminants trapped on the first porous member surface into the first subchamber; and opening the drain to generate a rapid velocity of dislodged particulate contaminants through the plurality of apertures into the second subchamber and out into the drain.

Another embodiment of the present invention comprises a fuel oil cleaning system and method that uses a reverse flow of clean fuel oil for cleaning a stationary porous member disposed in a fuel oil flow. To that end, the system comprises an inlet valve for controlling the fuel oil flow having particulate contaminants therein; the system also comprises a porous member having an input coupled to the inlet valve and wherein the porous member is in fluid communication with the fuel oil flow such that the fuel oil flow enters the porous member through a first porous member surface and exits through a second porous member surface. The fuel oil flow deposits the particulate contaminants on the first porous member surface and the fuel oil flow exits through the second porous member surface defining a clean fuel oil flow that flows out of the porous member at an output; the system further comprises an outlet valve coupled to the output for controlling the clean fuel oil flow; the system further comprises flow control means (e.g., a purge valve or other passive components such as a check valve and a flow restricting orifice) having a flow control means input coupled to a source of clean fuel oil and a flow control means output coupled to the output. The flow control means controls a reverse flow of the clean fuel oil from the second porous member surface through the first porous member surface for dislodging the particulate contaminants from the first porous member surface to form a contaminated reverse flow of fuel oil; the system further comprises a drain valve coupled to the input for directing the contaminated reverse flow of fuel oil; and finally, the system operates whereby the inlet valve and outlet valve are closed during cleaning and the flow control means and the drain valve are opened during cleaning.

The above invention also includes a method for cleaning a fuel oil flow having particulate contaminants therein. The method comprising the steps of: disposing a porous member in fluid communication with the fuel oil flow such that the fuel oil flow enters the porous member through a first porous member surface and exits through a second porous member surface so that the fuel oil flow deposits the

particulate contaminants on the first porous member surface; isolating the porous member from the fuel oil flow; sending a reverse flow of clean fuel oil through the porous member from the second porous surface member surface to the first porous member surface for dislodging the particulate contaminants from the first porous member surface to form a contaminated reverse flow of fuel oil; opening a drain to receive the contaminated reverse flow of fuel oil; and recoupling the porous member to the fuel oil flow.

DESCRIPTION OF THE DRAWINGS

Other objects and many of the intended advantages of this invention will be readily appreciated when the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawings wherein:

Fig. 1 is a block diagram of the fuel oil system in which the present invention is located;

Fig. 2 is a top view of the present invention;

Fig. 3 is a partial side view of the present invention;

Fig. 4 is a bottom view of the present invention;

Fig. 5 is a cross-sectional view of the present invention taken along line 5-5 of Fig. 2;

Fig. 6 is partial sectional view taken along line 6-6 of Fig. 5;

Fig. 7 is a partial sectional view taken along line 7-7 of Fig. 5;

Fig. 8 is a cross-sectional view of the present invention using a reverse flow of clean fuel oil as part of the particulate-removing means;

Fig. 9 is a partial sectional view taken along line 9-9 of Fig. 8;

Fig. 10 is similar to Fig. 9 except that a different reverse flow direction is depicted;

Fig. 11 is an enlarged, cross-sectional view of a portion of Fig. 5, depicting different portions of the partition and one of the associated wipers;

Fig. 12 is an enlarged, cross-sectional view of a portion of Fig. 5, depicting the passageways in the particulate-removing means support for use with the alternative drain configuration;

Fig. 13 is a partial isometric view of the internal particulate chamber depicting the partition and one of the wipers comprising the shoes;

Fig. 14 is a schematic of a fuel oil cleaning system using a stationary fuel oil strainer;

Fig. 15 is a variation of the fuel oil cleaning system of Fig. 14 wherein the downline fuel flow is used as the source of the reverse clean oil fuel flow; and

Fig. 16 is another variation of the invention of Fig. 15.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

The following is a detailed description of the present invention. The present invention has wide application where straining very small particulate contaminants, less than 100 microns and large percentage of these are less than 25 microns, from a fuel oil flow is required, and is not limited to the environment shown in Fig. 1, as will be discussed in detail below. The present invention is characterized as a non-disposable cleaning device, i.e., having a porous member that can be cleaned rather than being thrown away. The term non-disposable is defined as an item that does not require periodic replacement, e.g., once a day, week or month. Thus, such a non-disposable item has obvious advantages in environments where storage is limited and cleaning device replenishment facilities are unavailable, e.g., ocean-going vessels. Other example systems include power plants, cogeneration facilities, etc.

As an exemplary environment, Applicants have depicted a ship fuel oil system for disclosing the preferred embodiment. Referring now in greater detail to the various figures of the drawing, wherein like reference characters refer to like parts, there is shown in Fig. 1 at 20 an oil strainer of the present invention. The oil strainer 20 forms part of a compensated fuel system for use on watercraft, e.g., ships and boats. The compensated fuel oil system comprises a fuel oil service subsystem which includes a service tank 24 which is filled daily from a main fuel storage tank 22 with approximately one day's amount of fuel. The flow of fuel from the service tank 24 to the engine (which in the preferred embodiment is either a gas turbine or a diesel engine) must be a continuous fuel oil flow, as defined above, in that any interruption in that flow will shut down the main engines of the ship, thereby rendering the ship incapable of maneuvering. As such, there cannot be any shutdown of the flow, even to clean a fuel oil filter located therein. To meet this requirement, the self cleaning fuel

oil strainer 20 provides the means for filtering such a continuous fuel oil flow without interrupting that flow, as will be discussed below in detail.

As shown more clearly in Fig. 2, the fuel oil strainer 20 comprises two canisters 26 and 28 that are fed fuel oil from a common input manifold 30 (e.g., 2½ inch class 150 ANSI flanged input) at the top portion of the strainer 20. Each canister 26 and 28 has two inputs from the common manifold 30, as indicated by inputs 32A and 32B for canister 26 and by inputs 34A and 34B for canister 28. Each canister 26 and 28 comprises a cylindrical-shaped porous member 36 and 38, respectively, through which the fuel oil flows, as will be discussed in detail later. The porous members 36 and 38 comprise a screen selected from the group consisting of wedge wire, wire cloth and perforated metal. In the preferred embodiment, the porous members 36 and 38 comprise wedge wire screens, such as those manufactured by Leem Filtration Products, Inc. of Mahwah, New Jersey. It is also within the broadest scope of the present invention that the porous members 36 and 38 may comprise wire cloth or perforated metal, as opposed to wedge wire screens. One of the main features of the oil strainer 20 is its ability to filter out fine particulate matter, e.g., particulates less than 100 microns, where a large percentage of these are less than 25 microns.

Drive mechanisms 40 and 42 (Fig. 3) are provided to rotate the respective porous members 36 and 38 during the cleaning process about their respective center axes, only one (44) of which is clearly shown in Fig. 5. Otherwise, during normal operation, the porous members 36 and 38 remain stationary.

As can be seen in Fig. 2, fuel oil enters each canister through its respective inputs and then flows around the periphery of each porous member 36 and 38; in particular, fuel oil flow from inputs 32A and 32B are shown by arrows 46A and 46B, respectively, and fuel oil flow from inputs 34A and 34B are shown by arrows 48A and 48B, respectively. The inputs 32A and 32B are located on both sides of an internal particulate chamber 50 (Fig. 7, which comprises two dislodge subchambers 50A/50B and a drain subchamber 50C, all of which are discussed later) in canister 26; similarly, although not shown, the inputs 34A and 34B in canister 28 are also located on both sides of a internal particulate chamber, also comprising two dislodge subchambers and a drain subchamber. Thus, fuel oil input flow moves away from the chamber 50 and

around the periphery of the porous members 36 and 38 and then through them, as is discussed next.

Fuel oil flow through the porous member is more easily depicted in Fig. 5, which is a cross-sectional view of the canister 26, although it should be understood that the following discussion is applicable to the other canister 28. The main fuel oil flow is through the porous member 36, from an outside surface 37 to an inside surface 39, as indicated by the arrows 52, and down through the hollow interior 41 of the porous member 36. As the fuel oil then flows through the porous member 36, particulate contaminants are then trapped against the outer surface 37 of the porous member 36. The filtered fuel oil exits into a main output 54 of the canister, as shown by the arrow 56. Fig. 4 is a bottom view of both canisters 26 and 28 and it shows the main output 54 of canister 26 and a main output 58 of canister 28 feeding into a common output manifold 60. Thus, fuel oil flow through the strainer 20 is basically continuous.

When cleaning of the porous member 36 and 38 is required, as indicated by pressure drop across the strainer 20 (as measured by a pressure transducer, not shown), the drive mechanisms 40 and 42 are activated to rotate the respective porous members. In addition, solenoid valves 72 and 74 (Fig. 3) are activated to open respective drains (only one 76 of which is shown in Fig. 5), located directly below the drain subchamber 50C, for diverting the particulate debris and a limited amount fuel oil down through a respective drain, rather than through the main outlets 54 and 58. Furthermore, it is within the broadest scope of this invention to include other alternative locations for the drain, e.g., along the chamber, rather than under it, as will be discussed in detail later. Opening of the drain 76 (or the alternative drain) is kept to a minimum to discard as little fuel as possible while flushing the particulate contaminants from the chamber. Thus, for example, the drain 76 can be open all or any part of the time that the porous members 36 and 38 are rotating.

Cleaning of the porous members 36 and 38 is accomplished by the particulate-removing means, only one of which is shown most clearly in Figs. 5, 7, 8 and 9; as such, the following discussion applies to the particulate-removal means in the canister 28 also. In the preferred embodiment, the particulate-removing means comprises an elongated wire brush 62 that spans the length of the porous member 36.

The brush fibers are in contact with the outside surface 37 of the porous screen 36 and thus bear on the outside surface 37 of the porous member 36 along its entire length. The brush 62 forms the separation between the two dislodge subchambers 50A and 50B, while the majority of a brush support 63 is disposed inside the drain subchamber 50C, as shown in Fig. 7.

As mentioned previously, the chamber 50 comprises the two dislodge subchambers 50A/50B and a drain subchamber 50C. The chamber 50 comprises a pair of confining walls 64A and 64B, also running the length of the porous member 36, that enclose the brush 62/brush support 63. The purpose of these walls 64A and 64B is to contain the dislodged particulate debris within the chamber 50 so that substantially only fuel oil within this chamber 50 will be discharged through the drain 76 (or alternative drain 300, to be discussed later) during cleaning. A partition 200, also running the length of the porous member 36, forms the separation between the two dislodge subchambers 50A/50B and the drain subchamber 50C. The partition 200 itself comprises a pair of outer flanges 202A/202B, a base wall 204 and sidewalls 206A/206B. The base wall 204 is secured between a particulate-removing means (e.g., brush 62 or scraper) head 61 and the particulate-removing means support 63. At the bend between the sidewalls 206A/206B and the outer flanges 202A/202B, the partition 200 comprises a plurality of apertures 212 (Figs. 7, 9, 11 and 12) that permit the passage of dislodged particulate contaminants from the two dislodge subchambers 50A/50B to the drain subchamber 50C. Because of the size of the apertures 212 (e.g., 0.094" diameter), once any particulate contaminants from the two dislodge subchambers 50A/50B make their way through the partition 200, there is very little chance that such particulate contaminants can find their way back through the apertures 212 and ultimately return to the outer surface 37.

A drain passageway 75, through a strainer support housing 77, is also shown in Figs. 5. Figs. 7 and 9 also show the passageway 75 in phantom.

At the extreme ends of the confining walls 64A and 64B, respective wipers 65A and 65B are secured to the outside surfaces of the walls 64A and 64B, respectively, and which also run the length of the porous member 36. The wipers 65A and 65B (e.g., 316 stainless steel, half-hard) are coupled to the ends of the walls 64A and 64B using fasteners 78 and plates 79. As can be seen most clearly in Fig. 13,

wiper 65A comprises a plurality of spaced-apart shoes or runners 67 that are in contact with the outer surface 37 of the porous member 36. These shoes 67 (e.g., 0.010" - 0.015" thickness and 1/4" wide and which may be spot-welded to the wiper 65A) serve to maintain the wiper 65A a sufficient distance away from the outer surface 37 such that during cleaning, while the porous member 36 is rotating (direction of rotation is shown by the arrow 161 in Fig. 7), the particulate contaminants adhering to the outer surface 37 pass beneath the wiper 65A between the shoes and then are driven off of the outer surface 37 by the particulate-removing means 62 and into the dislodge subchamber 50A. The drain subchamber 50C is in direct fluid communication with the drain 76 (or alternative drain 300). When the drain 76 (or alternative drain 300) is open, any particulate contaminants suspended in the dislodge subchamber 50A are pulled toward the apertures 212 in the partition 200 and pass through them and out to the drain 76 (or 300).

Any remaining particulate contaminants which cannot be mechanically driven off of the surface 37 by the brush 62, e.g., particulate contaminants lodged in between the outer surface 37 and the inside surface 39 of the porous member 36 (e.g., lodged in the wedge wire cells of a porous member 36 comprising wedge wire), are subjected to a reverse pressure and are driven out of the surface 37 into the second dislodge subchamber 50B. In particular, unlike the first dislodge subchamber 50A which is not totally closed off since the wiper 65A stands off from the outside surface 37 of the porous member 36, the second dislodge subchamber 50B forms a completely-closed off chamber because the wiper 65B does not include shoes and, therefore, is in contact with the outer surface 37 along its entire length. Thus, the second dislodge subchamber 50B is subjected completely to the influence of the pressure differential created between the inside surface 39 of the porous member 36 and the opened drain pressure which is present in the drain subchamber 50C, via the apertures 212. When the drain 76 (or 300) is open, these particulate contaminants, lodged in between the outer surface 37 and the inside surface 39 of the porous member 36, are driven out of that region by the reverse pressure differential and then are suspended in the second dislodge subchamber 50B; this pressure differential also pulls these particulate contaminants toward the apertures 212 in the partition 200 and into the drain subchamber 50C for passage through the drain 76 (or 300).

As pointed out earlier, the particulate contaminants are of an extremely small size, less than 100 microns, and a large percentage of these are less than 25 microns; as a result, these particulate contaminants do not settle out by gravity into the drain but rather, due to their small size, remain suspended in the fuel oil. The invention of the present application is well suited to overcome this problem as described below.

It should be understood that the apertures 212 provide for fluid communication between the first dislodge subchamber 50A and the drain subchamber 50C and for fluid communication between the second dislodge subchamber 50B and the drain subchamber 50C. However, because the apertures 212 are small, they maintain a high velocity of particulate contaminants from both the first and second dislodge subchambers 50A and 50B into the drain subchamber 50C under the influence of the reverse pressure differential. Such a high velocity cannot be sustained by replacing the apertures 212 with a slot. Furthermore, replacing the apertures 212 with a slot would defeat the purpose of maintaining the transferred particulate contaminants (i.e., particulate contaminants that have passed from the dislodge subchambers 50A/50B) in the drain chamber 50B since the particulate contaminants would not be precluded from making their way back to the outer surface 37 of the porous member 36.

In particular, the advantage of using the plurality of apertures, as opposed to a slot of the type shown in U.S. Patent No. 5,595,655 (Steiner et al.), is that the plurality of apertures provides for a rapid flow velocity as opposed to a low flow velocity for the slot. For example, if there are 21 apertures that form one set of apertures in the partition 200, each having a diameter of approximately 0.094", then the total area is approximately $\pi (0.094"/2)^2 \times 21 = 0.1457 \text{ in}^2$. If, on the other hand, a slot having a width of 0.094" and a length of 12.594" (i.e., the length from the top of the uppermost aperture in the partition 200 to the bottom-most aperture in the partition 200; this is a reasonable assumption since the Steiner et al. patent states that the slot is substantially equal to the scraper length-Steiner et al. patent, col. 1, lines 61-62) is used, the area is 1.184 in². Thus, using a plurality of apertures presents only 1/8 the area of the slot. As a result, for a given flow rate (gallons/minute), the slot may provide flow velocity of 1 ft/sec for a given drain flow, whereas the apertured partition generates a flow velocity of 8 ft/sec for a given drain flow. The higher velocity

significantly reduces the chance that a particulate will migrate backwards through the plurality of apertures and re-attach to the porous surface 36.

It is also within the broadest scope of the present invention to include an alternative drain 300 configuration as shown most clearly in Figs. 5, 8 and 12. To that end, a drain 300 is depicted along side the drain subchamber 50C rather than disposed underneath the subchamber 50C, as discussed previously. The drain 300 comprises drain passageways 302, 304 and 306 that form a portion of the particulate-removing means support 63. The passageways 302-306 are coupled at one end to a common manifold 308 through which the dislodged particulate contaminants are disposed of. As shown in Fig. 12, the other end of each passageway 302-306 comprises a respective cross hole 310, 312, and 314 disposed in the drain subchamber 50B. Thus, when a drain solenoid valve 316 (Fig. 5) is activated as discussed previously, particulate matter that has been dislodged from the outer surface 37 of the porous members 36/38 into the two dislodge subchambers 50A/50B, passes through the apertures 212 in the partition 200 into the drain chamber 50B. From there, the dislodged particulate contaminants are driven into the cross holes 310-314, through the passageways 302-306 and then into the common manifold 308. Thus, particulate contaminants dislodged from the outer surface 37 of the porous members 36/38 would be driven into the alternative drain 300.

Alternatively, instead of using a single solenoid valve 316, it is within the broadest scope of this invention to include dedicated solenoid valves 318, 320 and 322 (Fig. 5) that individually couple respective passageways 302-306 to the common manifold 308.

It is also within the broadest scope of the present invention that the term particulate-removing means include a brush, a scraper, or any equivalent device that is used to dislodge particulate contaminants from the outside surface 37 of the porous members 36 and 38. For example, where larger particulate contaminants are to be filtered from the fuel oil flow, a scraper (not shown) can be used in place of the brush 62.

As shown in Fig. 1, the oil strainer 20 can also be used in the fuel oil transfer subsystem portion of the compensated fuel oil system, with a few modifications. For example, the input 31 and the output 61 of the oil strainer 20 used

in the fuel oil transfer subsystem would be greater in size (as compared to the input 30 and output 60 of the oil strainer 20 used in the fuel oil service system discussed previously) to accommodate the larger fuel flow in that subsystem. In addition, the porous members 36 and 38 may need to only filter out particulate matter as small as 25 microns. In all other aspects, the oil strainer 20 used in the fuel oil transfer subsystem is similar to the oil strainer 20 used in the fuel oil service system. (The fuel oil transfer subsystem comprises the main fuel storage tank 22 in which sea water is used to replace fuel used).

It is also within the broadest scope of the present invention that the particulate-removing means also encompasses a reverse flow of clean fuel oil for dislodging the particulate contaminants from the fuel oil filter; or a reverse flow of clean fuel oil in combination with the particulate-removing member (e.g., brush or scraper), discussed previously.

In particular, as shown in Figs. 8-10, a second embodiment of the present invention comprises a particulate-removing means that includes an elongated spraying element 151 comprising a plurality of ports 153. The elongated spraying element 151 is coupled to a pressure source 155 (e.g., a pump, air supply, etc.) that recirculates clean fuel oil (whose flow is indicated by the arrow 56) into the elongated spraying element 151, during cleaning only, to create a high energy fuel oil spray that emanates from each of the ports 153. As shown most clearly in Fig. 9, the direction of the high energy spray (indicated by the arrow 157) is from the inside surface 39 to the outside surface 37 of the porous member 136. Thus, as the porous member 36 is rotated (direction indicated by the arrow 161) during cleaning, the high energy spray drives the particulate contaminants from the outside surface 39 into the dislodge subchamber 50B.

It should be understood that the particulate-removing means may comprise the elongated spraying element 151 alone for driving off the particulate contaminants, or the particulate-removing means may comprise a particulate-removing member (e.g., a brush 62 or scraper) in addition to the elongated spraying element 151, as shown in Figs. 8-9. Together, the elongated spraying element 151 and the particulate-removing member (e.g., brush 62 or scraper) act to dislodge the particulate contaminants from the outside surface 37 of the porous member 36 during cleaning.

When the particulate-removing member (e.g., a brush 62 or scraper) is used in combination with the elongated spraying element 151, the direction of the high energy spray (indicated by the arrow 163) may be set to occur after the particulate-removing member dislodges some of the particulate contaminants (Fig. 10), thereby driving particulate contaminants into the second dislodge subchamber 50B.

The porous member 36, for use in this second embodiment, comprises an open lower end 137 (Fig. 8) to permit passage of the elongated spraying element 151 therethrough.

Another variation of the self-cleaning fuel oil filter that utilizes a reverse flow of clean fuel oil for cleaning purposes is depicted at 220 in Fig. 14. In particular, as indicated by the arrow 165, during normal operation, contaminated fuel oil enters through an inlet valve 167 to a fuel oil filter 220. During normal operation, a drain valve 171 and a purge valve 173 remain closed, as will be discussed in detail later. The fuel oil filter 220 comprises a porous member 236, preferably having a wire cloth configuration. The direction of the fuel oil flow through the porous member 236 is given by the arrows 52 and is similar to the flow for the porous members discussed previously, i.e., from an outside surface 37 of the porous member 236 to an inside surface (not shown) of the porous member 236 and then through the center portion 41 of the porous member 236. The cleaned fuel oil is then passed through an outlet valve 175 in the direction of the arrow 177.

The cleaning process for the fuel oil filter 220 is different from the previous embodiments in that the porous member 236 does not move during cleaning. Instead, a reverse flow of clean fuel oil (the direction of this reverse flow is given by the arrow 179) is injected down through the center of the porous member 236, from the inside surface to the outside surface 37 of the porous member 236. This reverse flow of clean fuel oil impacts the entire inside surface of the porous member 236 and flows to the outside surface 37 of the porous member 236, thereby dislodging the particulate contaminants from the outside surface 37 of the porous member 236. Since this reverse flow acts through the entire porous member 236, there are no confining walls used. Thus, in this embodiment, the particulate removal means comprises only the reverse flow of clean fuel oil. Because this reverse flow of clean fuel oil is applied

through the entire porous member 236, the fuel oil filter 220 must be isolated from the normal fuel oil flow during cleaning, as will be discussed in detail below.

In particular, when cleaning is required, the inlet valve 167 and outlet valve 175 are closed and the purge valve 173 and drain valve 171 are opened. The purge valve 173 is coupled to a clean fuel reservoir 181 which is under pressure (e.g., an air supply, whose input flow is indicated by the arrow 183 and having a valve 185 for maintaining air pressure in the reservoir 181. The downstream clean fuel, indicated by the arrow 187, enters the reservoir 181 through a recharge valve 189). When the purge valve 173 is opened, the reverse flow of clean fuel oil 179 drives the particulate contaminants off of the outside surface 37 of the porous member 236. Since the drain valve 171 is also opened, the reverse flow, now containing the dislodged particulate contaminants, flows out, as indicated by the arrow 191, through the drain valve 171. Once this flow of dislodged particulate contaminants passes to the drain, the purge valve 173 and the drain valve 171 are closed and the input valve 167 and the output valve 175 are opened, restoring normal fuel oil flow.

It should be understood that the continuous fuel oil flow is accomplished by having a plurality (e.g., five to eight) parallel, non-rotating filter paths (not shown) that are coupled to the reservoir 181 through respective purge valves 173. Thus, when any one non-rotation filter path is being cleaned using the reverse fuel oil flow, the remaining parallel channels are operating under the normal fuel oil flow.

Another variation of this embodiment, depicted in Fig. 15, uses the downstream clean fuel oil directly to create the reverse fuel oil flow. In particular, the purge valve 173 is coupled directly to the downstream clean fuel oil flow. The sequence of valve openings/closings are similar to that described previously. Thus, when the purge valve 173 and the drain valve 171 are opened, the reverse flow of clean fuel oil, the direction indicated by the arrow 179, is generated directly from the downstream clean fuel oil flow.

Another variation of this embodiment is shown in Fig. 16 that uses passive components such as a check valve 400 and a flow restricting orifice 402 in place of the purge valve 173.

It should also be understood that the variations of Figs. 15 and 16, like that discussed with regard to Fig. 14, also comprise a plurality of parallel, non-rotating

filter paths that permit the continuous flow of fuel oil when any one of the parallel, non-rotating filter paths is being cleaned by the reverse flow of clean fuel oil.

Without further elaboration, the foregoing will so fully illustrate our invention and others may, by applying current or future knowledge, readily adapt the same for use under various conditions of service.

CLAIMS

1. A fuel oil cleaning device disposed within a continuous fuel oil flow having particulate contaminants therein, said cleaning device comprising:

 a porous member in fluid communication with the fuel oil flow such that the fuel oil flow enters said porous member through a first porous member surface and exits through a second porous member surface, said fuel oil flow depositing the particulate contaminants on said first porous member surface;

 particulate-removing means disposed to be in close proximity with said porous member for removing particulate contaminants from said first porous member surface along substantially the entirety of the length of said first porous member surface;

 a pair of flow confining walls disposed to be in close proximity with said first porous member surface along substantially the entirety of the length of said first porous member surface for defining a chamber;

 a partition dividing said chamber into a first subchamber and a second subchamber along the length of said chamber;

 a drive mechanism for displacing said porous member for continuously directing particulate contaminants deposited on said first porous surface past the particulate removing means for continuously dislodging the particulate contaminants from said first porous member surface into said first subchamber;

 said partition including first and second portions on opposite sides of said particulate removing means and each portion having a plurality of apertures for passing the dislodged particulate contaminants from said first subchamber into said second subchamber; and

a drain being in communication with said second subchamber and through which the dislodged particulate contaminants are removed when said drain is opened.

2. The fuel oil cleaning device of Claim 1 wherein when said drain is opened a drain flow is created and wherein said plurality of apertures are of sufficient area to generate a rapid velocity of dislodged particulates from said first subchamber into said second subchamber.

3. The fuel oil cleaning device of Claim 2 wherein said plurality of apertures are linearly arranged to define an effective aperture length and wherein each aperture comprises a diameter, said rapid velocity of dislodged particulate contaminants being approximately eight times a velocity of dislodged particulate contaminants established by a slot having said effective aperture length and a width comprising said diameter for a given drain flow.

4. The fuel oil cleaning device of Claim 1 wherein said particulate removing means comprises a brush or scraper closely adjacent said first porous member surface and wherein said first subchamber is divided into a first dislodge subchamber and a second dislodge subchamber by said particulate-removing means and wherein:

 said first dislodge chamber is formed between said first porous member surface, one of said confining walls, said brush or scraper, said partition and a first flexible member disposed between said one of said confining walls and said first porous member surface; and

 said second dislodge chamber is formed between said first porous member surface, the other of said confining walls, said brush or scraper, said partition and a second flexible member that is disposed between said other of said confining walls and said first porous member surface.

5. The fuel oil cleaning device of Claim 4 where said first flexible member comprises a plurality of shoes that are in contact with said first porous member surface for disposing said first flexible member closely adjacent said first porous member surface.

6. The fuel oil cleaning device of Claim 4 wherein said first flexible member is disposed away from said first porous member surface in the range of 0.010 inches to 0.015 inches.

7. The fuel oil cleaning device of Claim 1 wherein said particulate-removing means comprises a spraying element positioned closely adjacent said second porous member surface and opposite said pair of confining walls for generating a reverse flow of clean oil, said reverse flow being directed from said second porous member surface through said first porous member surface for dislodging the particulate contaminants away from said first porous member surface into said first subchamber.

8. The fuel oil cleaning device of Claim 7 wherein said spraying element comprises an elongated lumen comprising a plurality of ports and coupled to a pressure source to clean fuel oil.

9. The fuel oil cleaning device of Claim 1 wherein said particulate removing means comprises a brush or scraper and wherein said drain comprises:

a plurality of particulate-removing means supports
that include respective internal passageways that are in
fluid communication with said second subchamber;

a common manifold to which said respective internal
passageways are coupled; and

a drain valve coupled to said common manifold for
controlling the opening and closing of said drain.

10. The fuel oil cleaning device of Claim 1 wherein said particulate removing means comprises a brush or scraper and wherein said drain comprises:

a plurality of brush or scraper supports that include respective internal passageways that are in fluid communication with said second subchamber;

a respective passageway valve coupled to each passageway for controlling the passage of particulate contaminants through said respective passageway; and

a common manifold coupled to said respective passageway valves for conveying particulate contaminants out of said passageways.

11. The fuel oil cleaning device of Claim 1 wherein said porous member comprises a cylindrical-shaped filter and wherein said first porous member surface is the outer surface of said cylindrical-shaped filter and wherein said second porous member surface is the inner surface of said cylindrical-shaped filter.

12. The fuel oil cleaning device of Claim 11 wherein said drive mechanism displaces said filter by causing it to rotate.

13. The fuel oil cleaning device of Claim 12 wherein said confining walls comprise respective outer surfaces away from said member and wherein said fluid communication comprises a first input fuel oil flow and a second input fuel oil flow on a respective outer surface away from said member.

14. The fuel oil cleaning device of Claim 1 wherein said porous member traps particulate contaminants as small as approximately 25 microns.

15. The fuel oil cleaning device of Claim 14 wherein said porous member comprises a screen selected from the group consisting of wedge wire, wire cloth and perforated metal.

16. The fuel oil cleaning device of Claim 7 wherein said cylindrical-shaped filter screen comprises a screen selected from the group consisting of wedge wire, wire cloth and perforated metal.

17. The fuel oil cleaning device of Claim 16 wherein said cylindrical-shaped filter screen comprises a wedge wire configuration for trapping particulate contaminants.

18. The fuel oil cleaning device of Claim 17 wherein said cylindrical-shaped filter screen comprises a wedge wire configuration for trapping particulate contaminants as small as approximately 25 microns.

19. A fuel oil cleaning system for use with a fuel oil flow having particulate contaminants therein, said cleaning system comprising:

an inlet valve for controlling the fuel oil flow having particulate contaminants therein;

a porous member having an input coupled to said inlet valve, said porous member being in fluid communication with the fuel oil flow such that the fuel oil flow enters said porous member through a first porous member surface and exits through a second porous member surface, said fuel oil flow depositing the particulate contaminants on said first porous member surface, said fuel oil flow exiting through said second porous member surface defining a clean fuel oil flow that flows out of said porous member at an output;

an outlet valve coupled to said output for controlling said clean fuel oil flow;

a flow control means having a flow control means input coupled to a source of clean fuel oil and a flow control means output coupled to said output, said flow control means controlling a reverse flow of said clean fuel oil from said second porous member surface through said first porous member surface for dislodging the particulate contaminants from

said first porous member surface to form a contaminated reverse flow of fuel oil;

a drain valve coupled to said input for directing said contaminated reverse flow of fuel oil; and

said inlet valve and outlet valve being closed during cleaning and said flow control means and said drain valve being opened during cleaning.

20. The fuel oil cleaning system of Claim 19 wherein said source of clean fuel oil is a pressurized fuel oil reservoir.

21. The fuel oil cleaning system of Claim 19 wherein said source of clean fuel oil is clean fuel oil that has passed thorough said outlet valve.

22. The fuel oil cleaning system of Claim 19 wherein said porous member comprises a cylindrical-shaped filter and wherein said first porous member surface is the outer surface of said cylindrical-shaped filter and wherein said second porous member surface is the inner surface of said cylindrical-shaped filter.

23. The fuel oil cleaning system of Claim 22 wherein said cylindrical-shaped filter comprises a wire cloth configuration.

24. The fuel oil cleaning system of Claim 19 wherein said flow control means comprises a purge valve.

25. The fuel oil cleaning system of Claim 19 wherein said flow control means comprises a check valve and a flow restricting orifice.

26. A method for cleaning a fuel oil flow having particulate contaminants therein, said method comprising the steps of:

disposing a porous member in fluid communication with the fuel oil flow such that the fuel oil flow enters said porous member through a

first porous member surface and exits through a second porous member surface so that the fuel oil flow deposits the particulate contaminants on said first porous member surface;

positioning a pair of flow confining walls adjacent said first porous member surface to define a chamber and positioning a respective flexible member between a respective flow confining wall and said first porous surface member, said respective flexible members being in contact with said first porous surface;

positioning a particulate-removing means closely-adjacent said porous member;

dividing said chamber into first and second subchambers with a partition having first and second portions on opposite sides of said particulate removing means and each portion having a plurality of apertures to provide fluid communication between said first and second subchambers, said second subchamber being in fluid communication with a drain when the drain is opened;

displacing said porous member to permit said particulate-removing means to dislodge particulate contaminants trapped on said first porous member surface into said first subchamber; and

opening the drain to cause the dislodged particulate contaminants to pass through said plurality of apertures into said second subchamber and out into the drain.

27. The method of Claim 26 wherein one of said respective flexible members is positioned to be in contact with said first porous member surface at discrete locations.

28. The method of Claim 27 wherein said step of displacing said porous member comprises displacing said first porous member surface transversely

in front of said particulate-removing means in a first direction, said first porous member surface passing said one of said respective flexible members that is in contact with said first porous member surface at discrete locations before passing in front of said particulate-removing means.

29. The method of Claim 26 wherein said particulate removing means comprises a brush or scraper positioned closely adjacent said first porous member surface.

30. The method of Claim 26 wherein said particulate removing means comprises a spraying element positioned closely adjacent said second porous member surface opposite said pair of confining walls for generating a reverse flow of clean oil, said reverse flow being directed from said second porous member surface through said first porous member surface for dislodging the particulate contaminants away from said first porous surface into said first subchamber.

31. A method for cleaning a fuel oil flow having particulate contaminants therein, said method comprising the steps of:

disposing a porous member in fluid communication with the fuel oil flow such that the fuel oil flow enters said porous member through a first porous member surface and exits through a second porous member surface so that the fuel oil flow deposits the particulate contaminants on said first porous member surface;

isolating said porous member from the fuel oil flow;

sending a reverse flow of clean fuel oil through said porous member from said second porous surface member surface to said first porous member surface for dislodging the particulate contaminants from said first porous member surface to form a contaminated reverse flow of fuel oil;

opening a drain to receive said contaminated reverse flow of fuel oil; and

recoupling said porous member to the fuel oil flow.

32. The method of Claim 31 wherein said step of disposing said porous member in fluid communication with the fuel oil flow comprises positioning a cylindrical-shaped filter screen in the fuel oil flow such that said first porous member surface is the outer surface of said cylindrical-shaped filter screen and wherein said second porous member surface is the inner surface of said cylindrical-shaped filter screen.

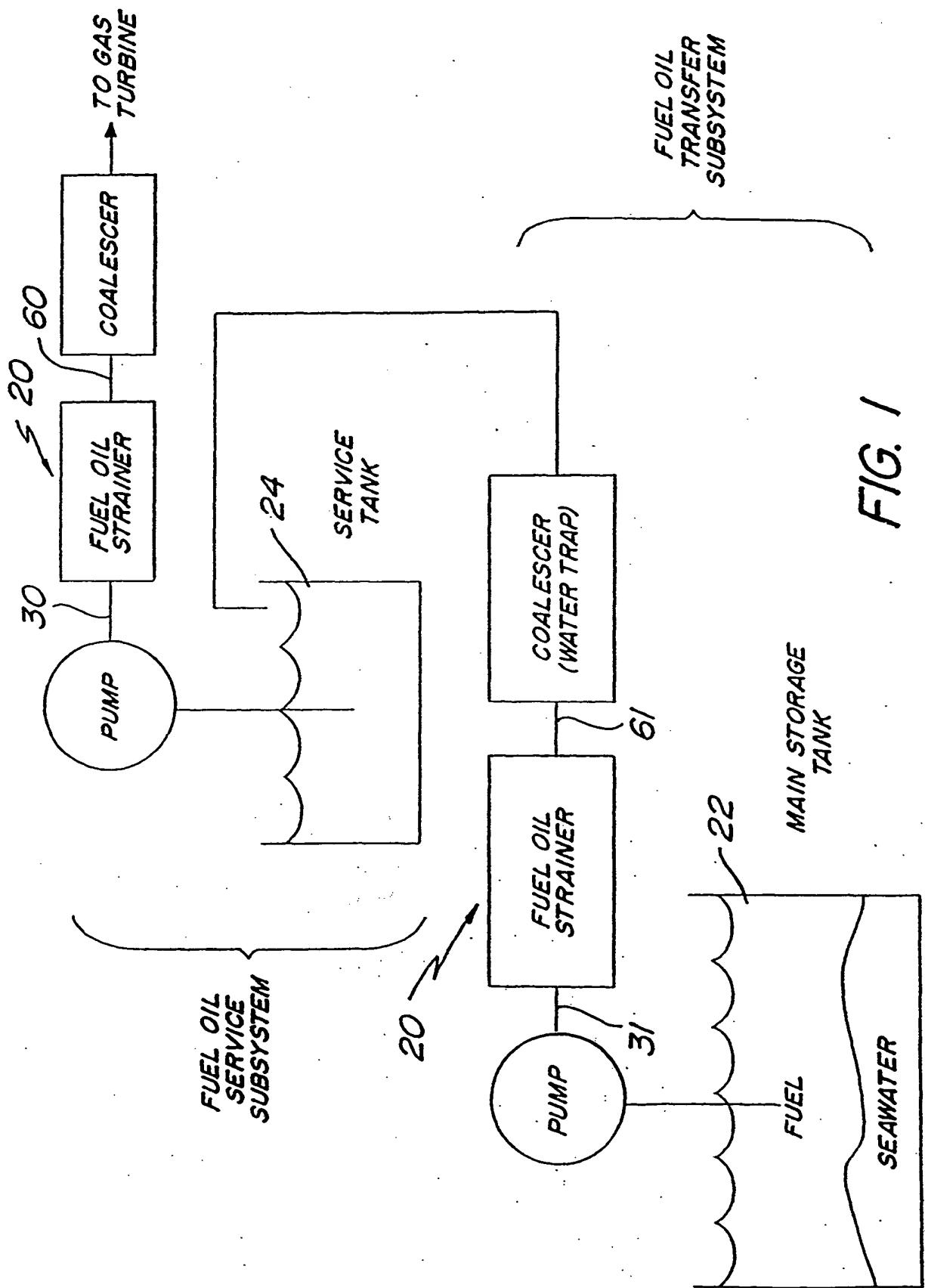


FIG. 2

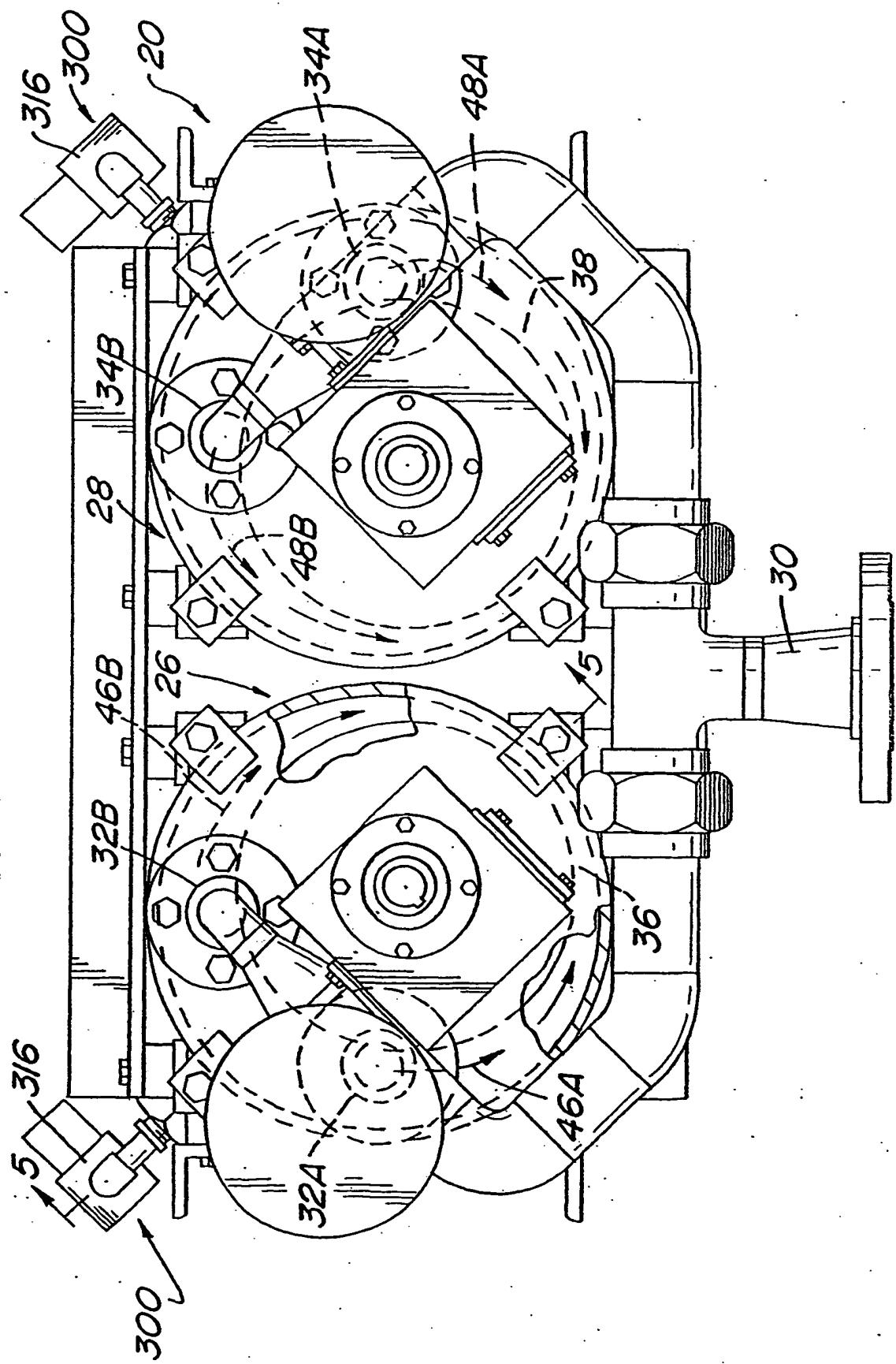
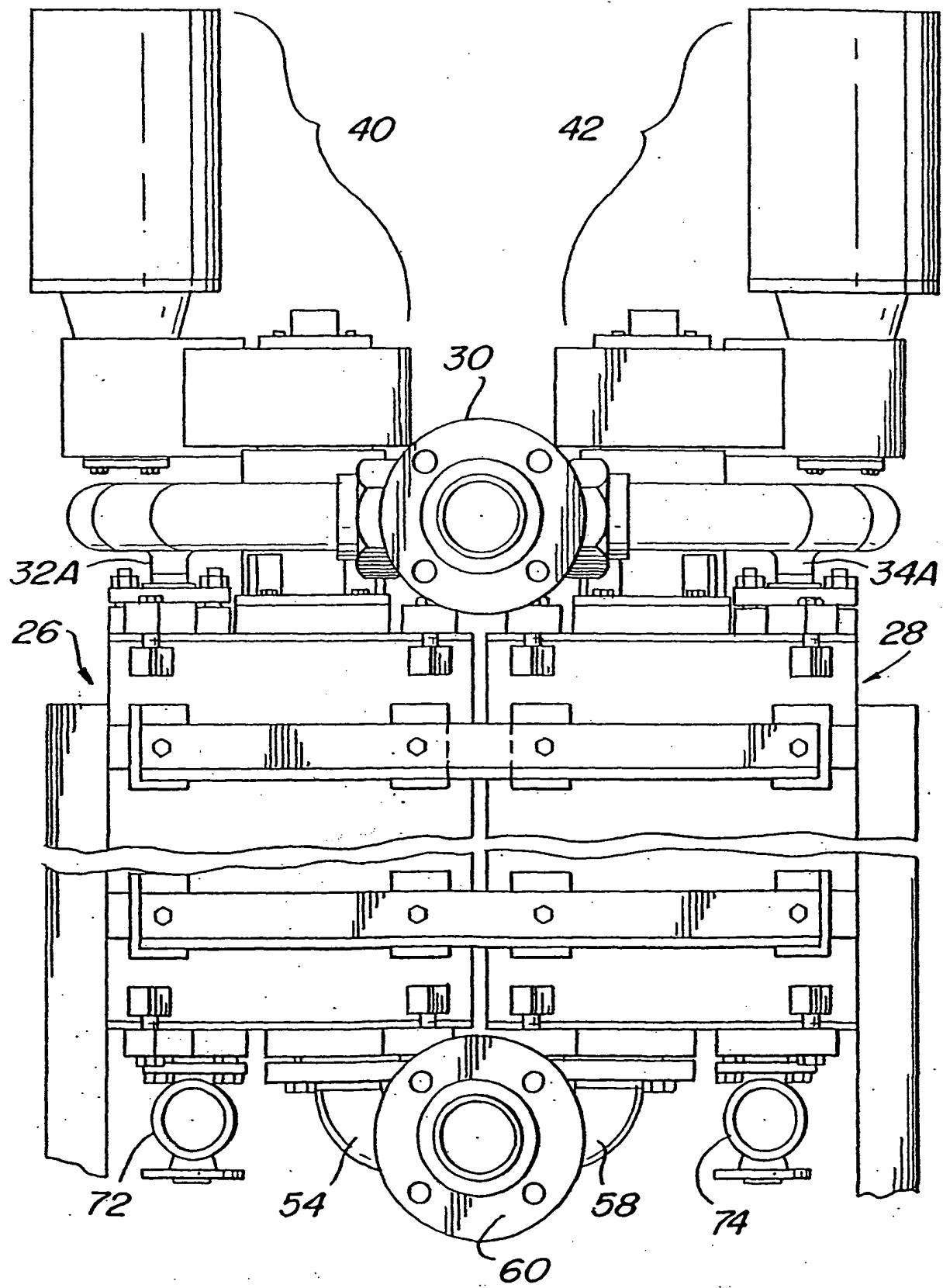


FIG. 3



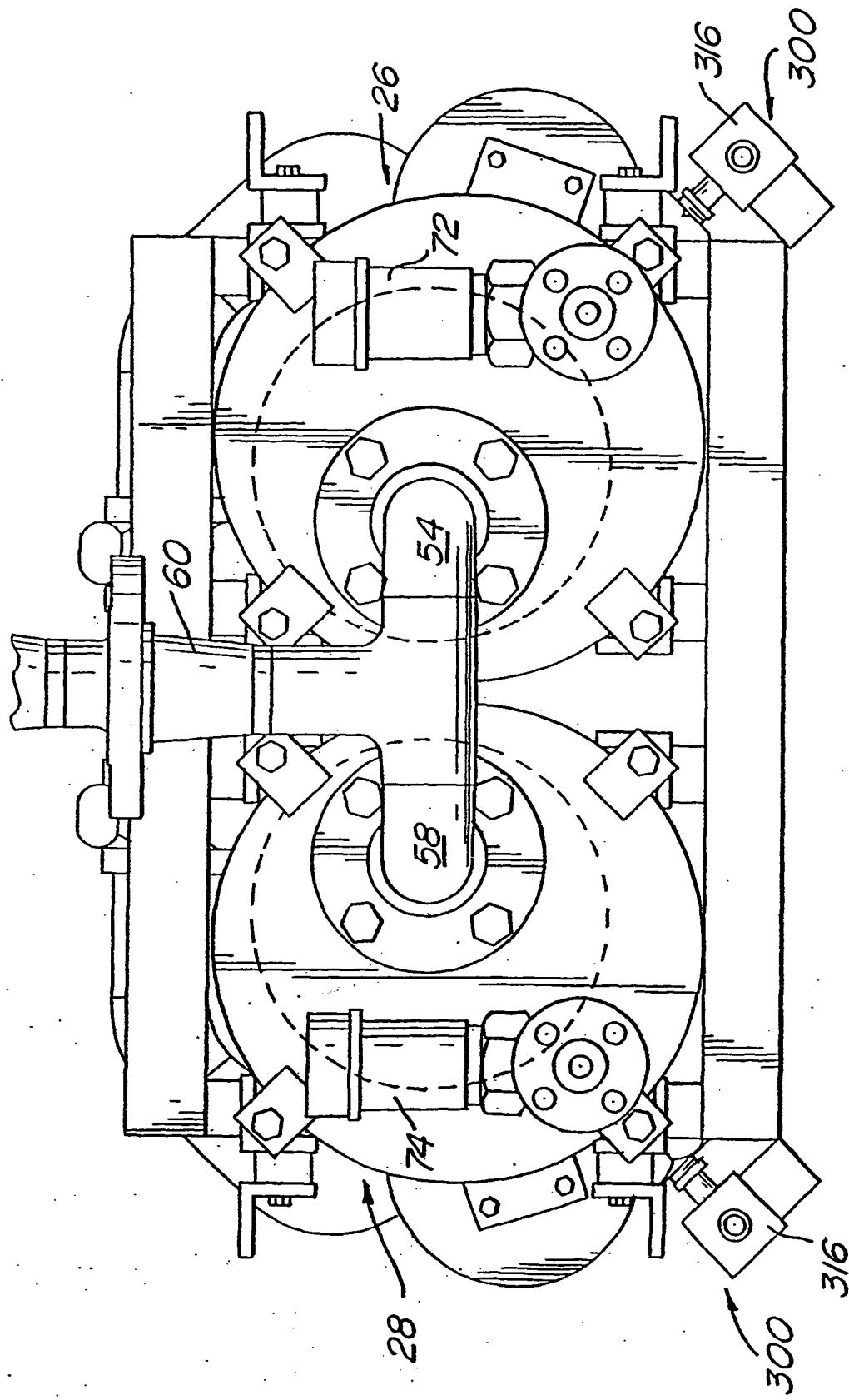


FIG. 4

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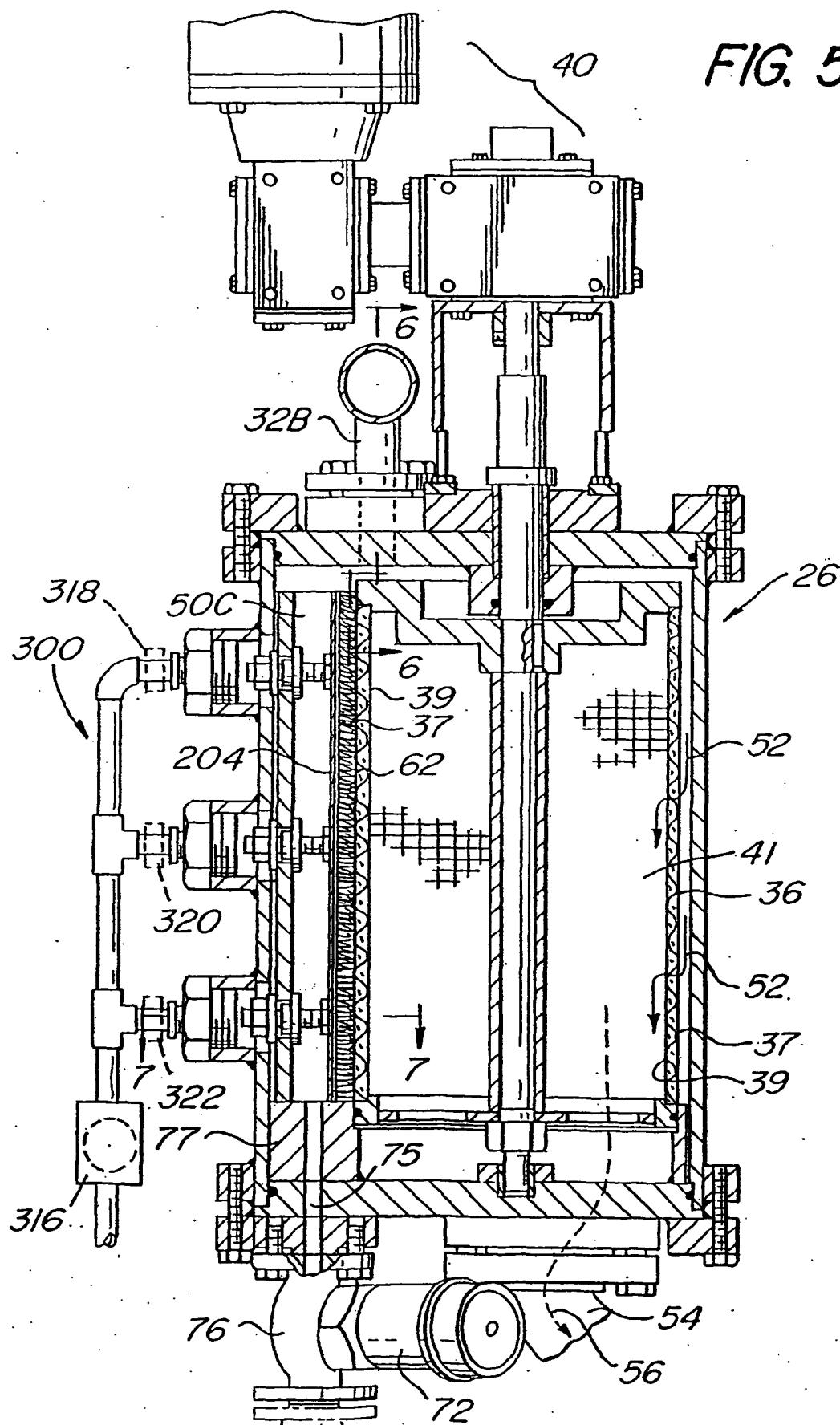


FIG. 6

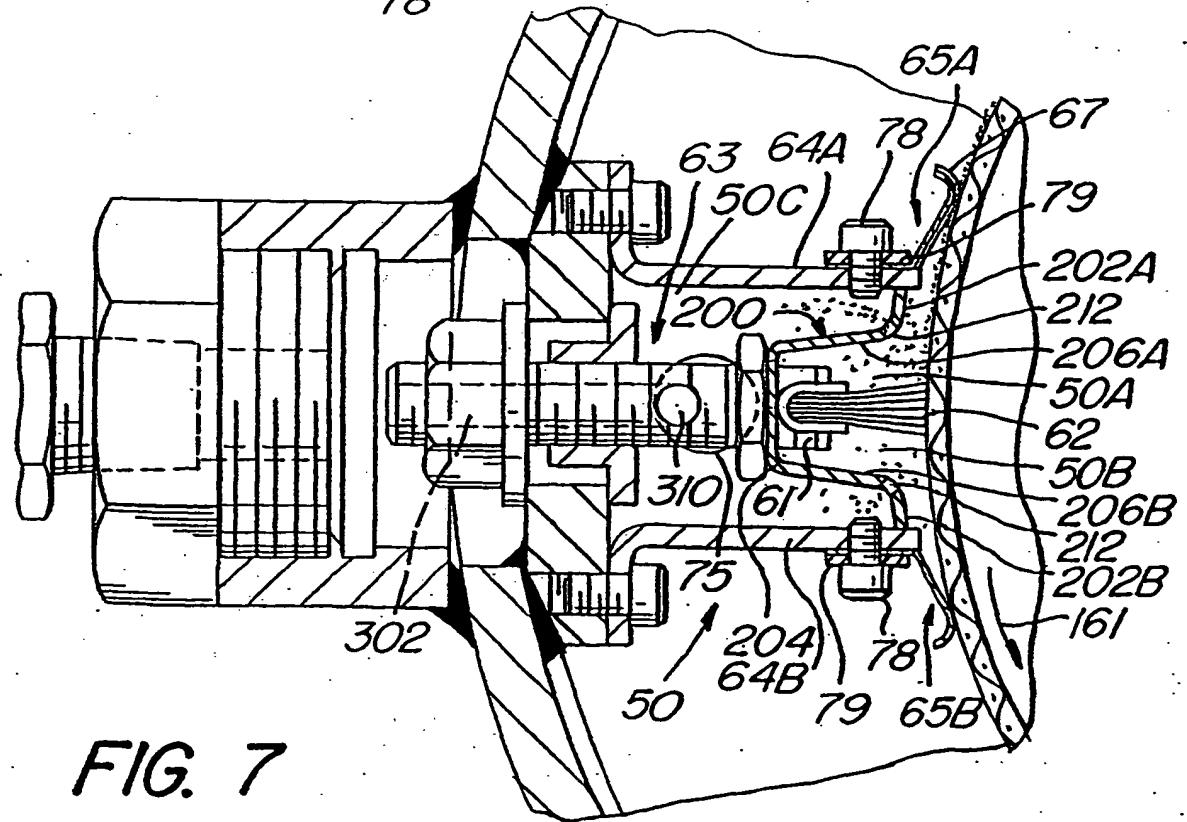
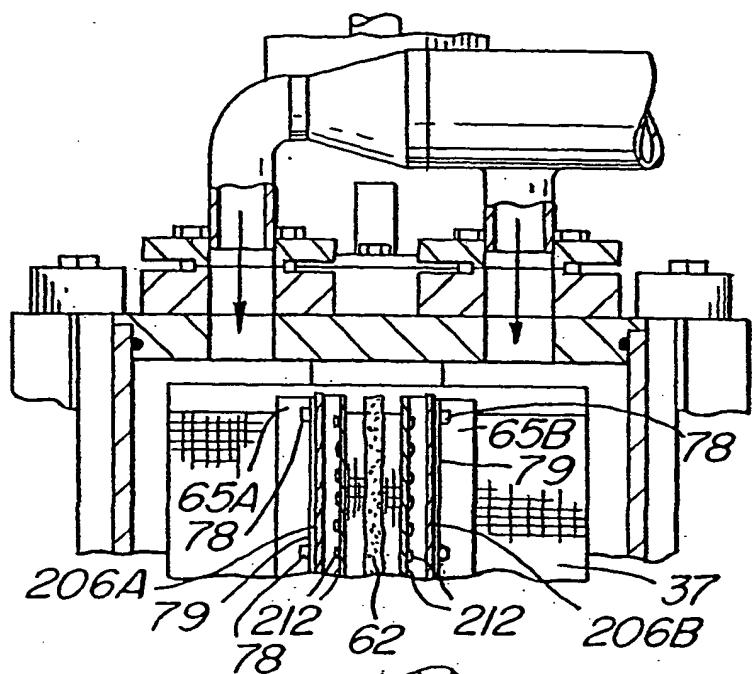


FIG. 7

FIG. 8

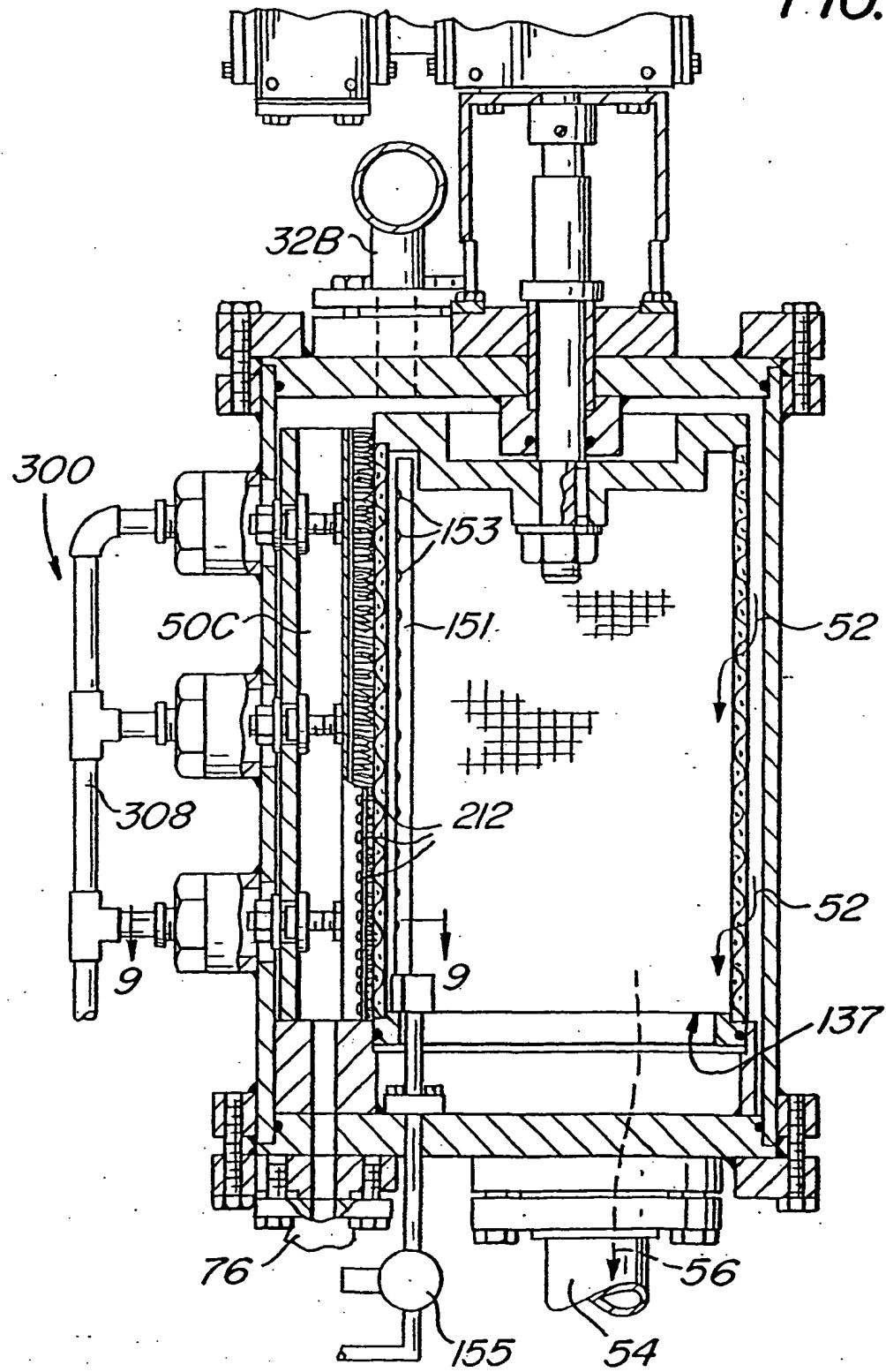


FIG. 9

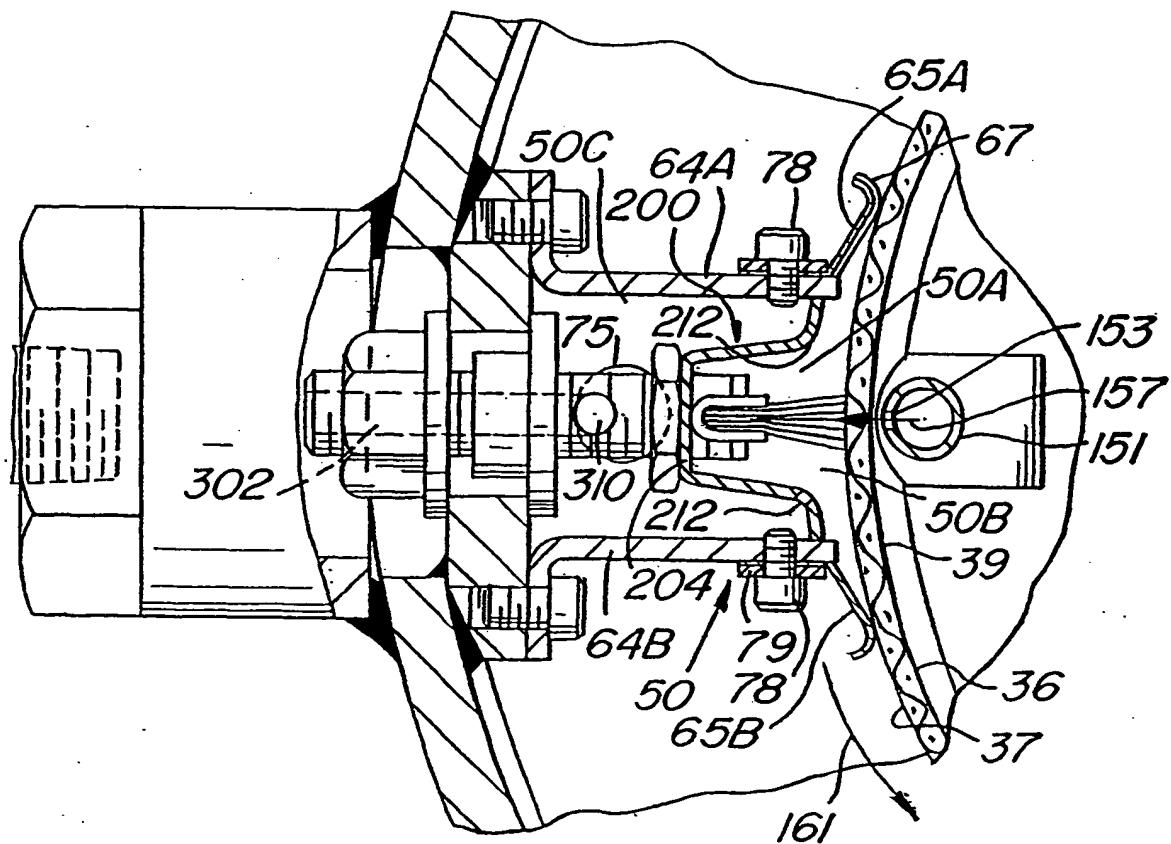


FIG. 10

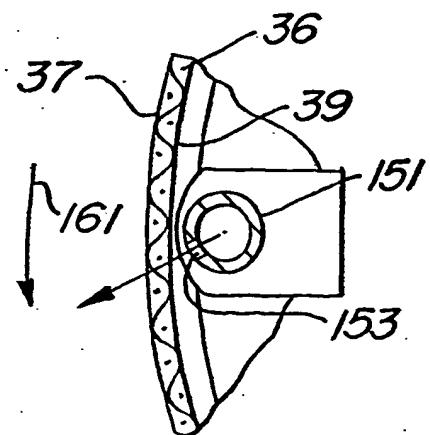


FIG. 11

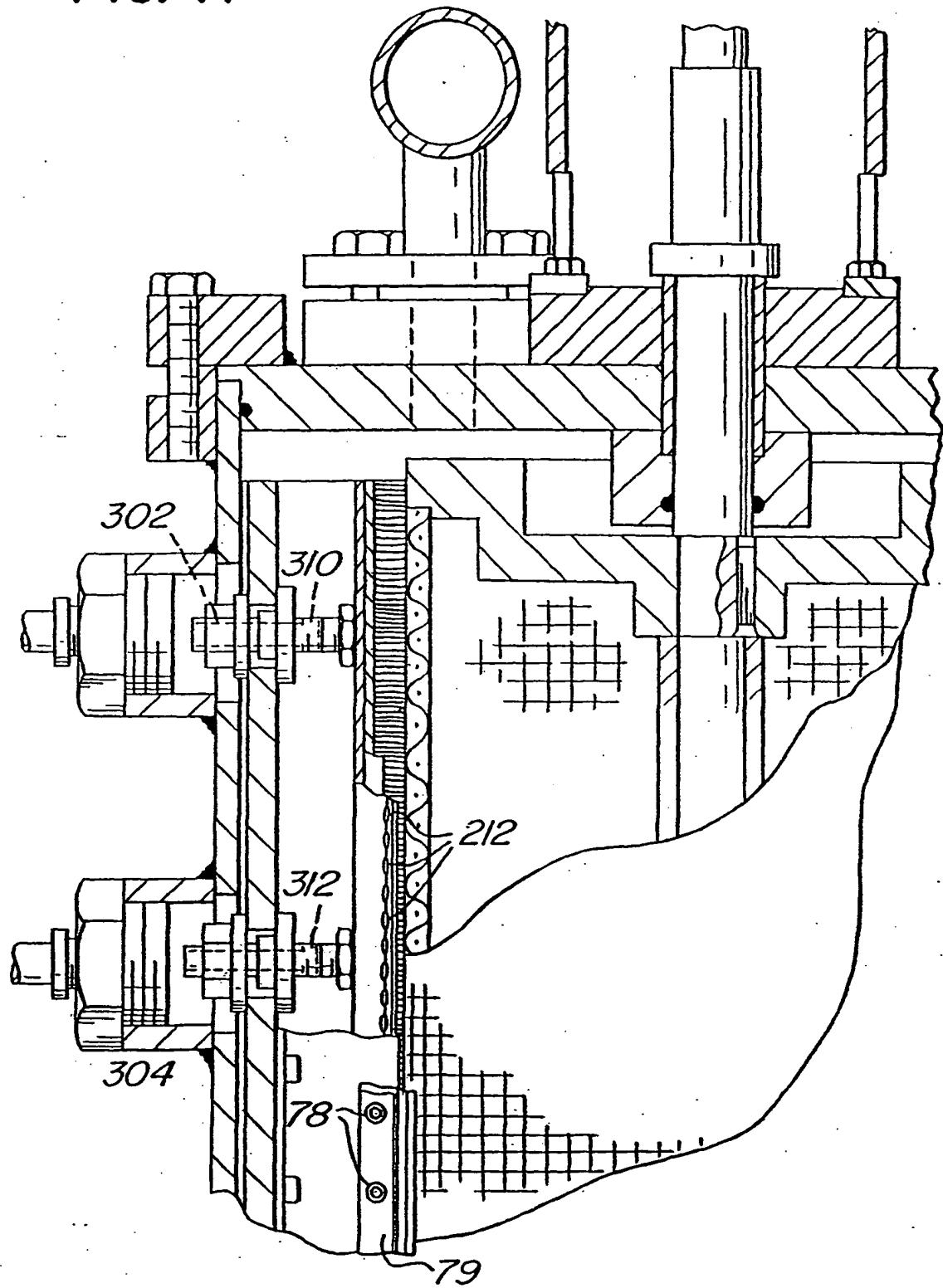
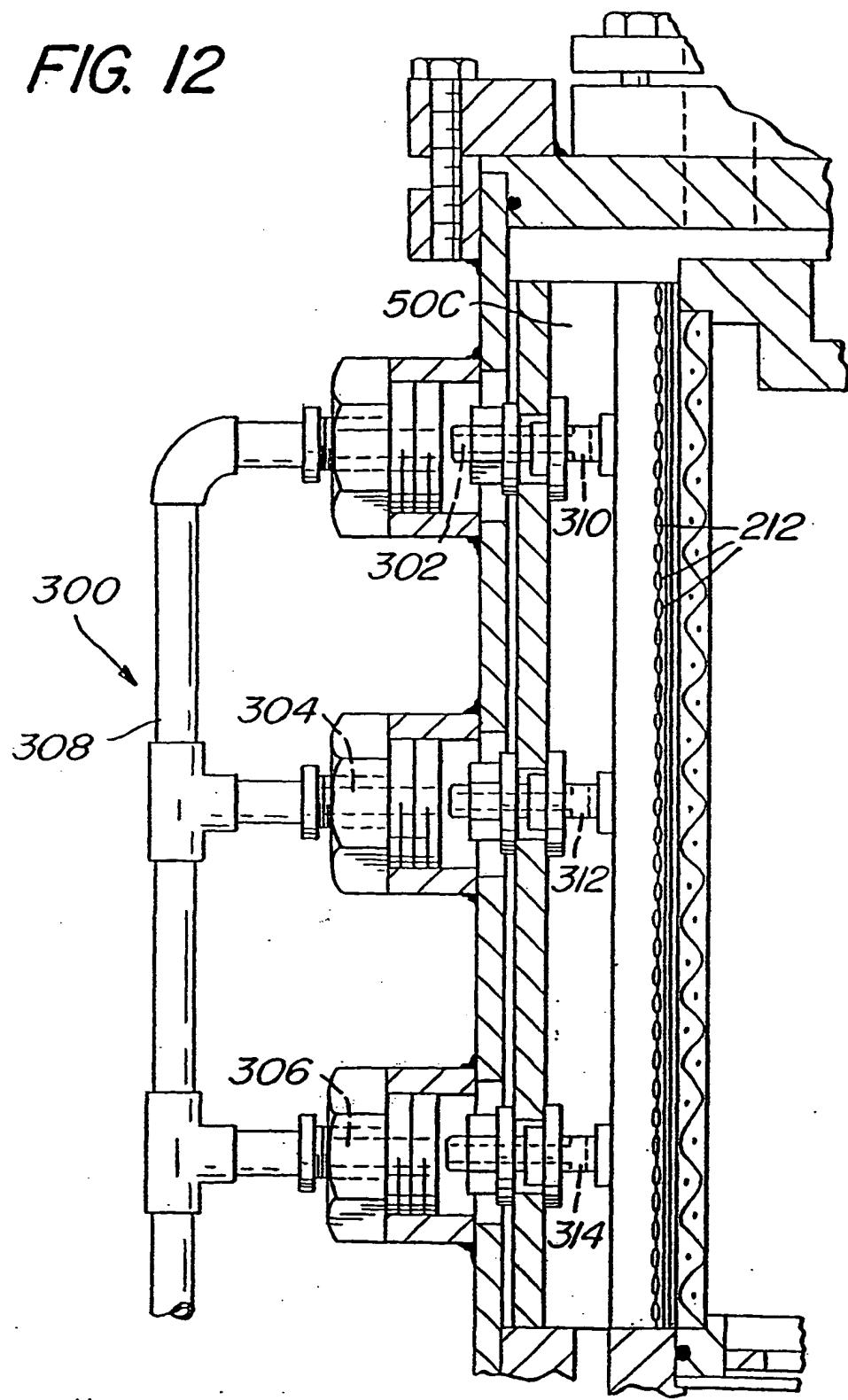


FIG. 12



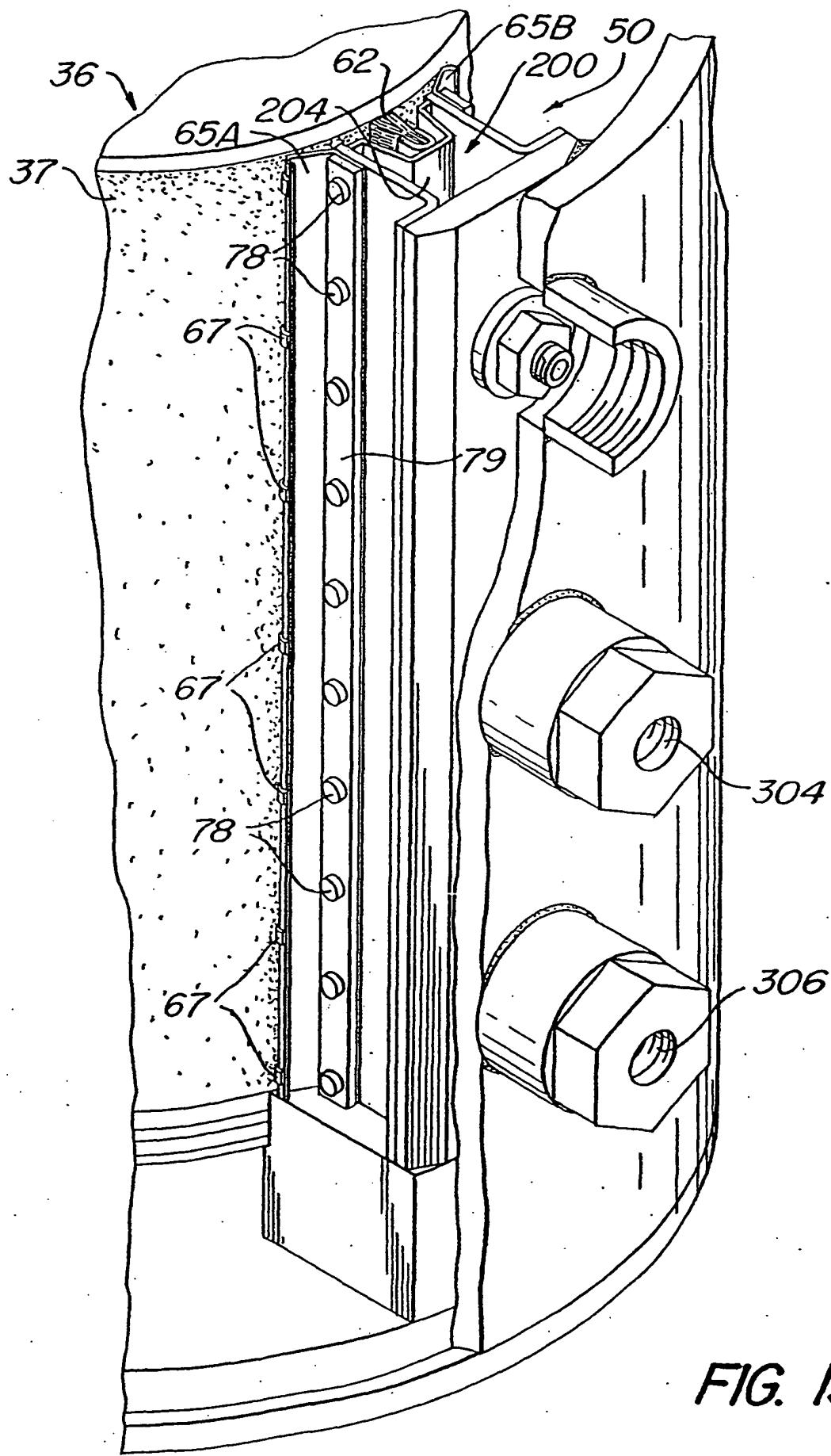


FIG. 14

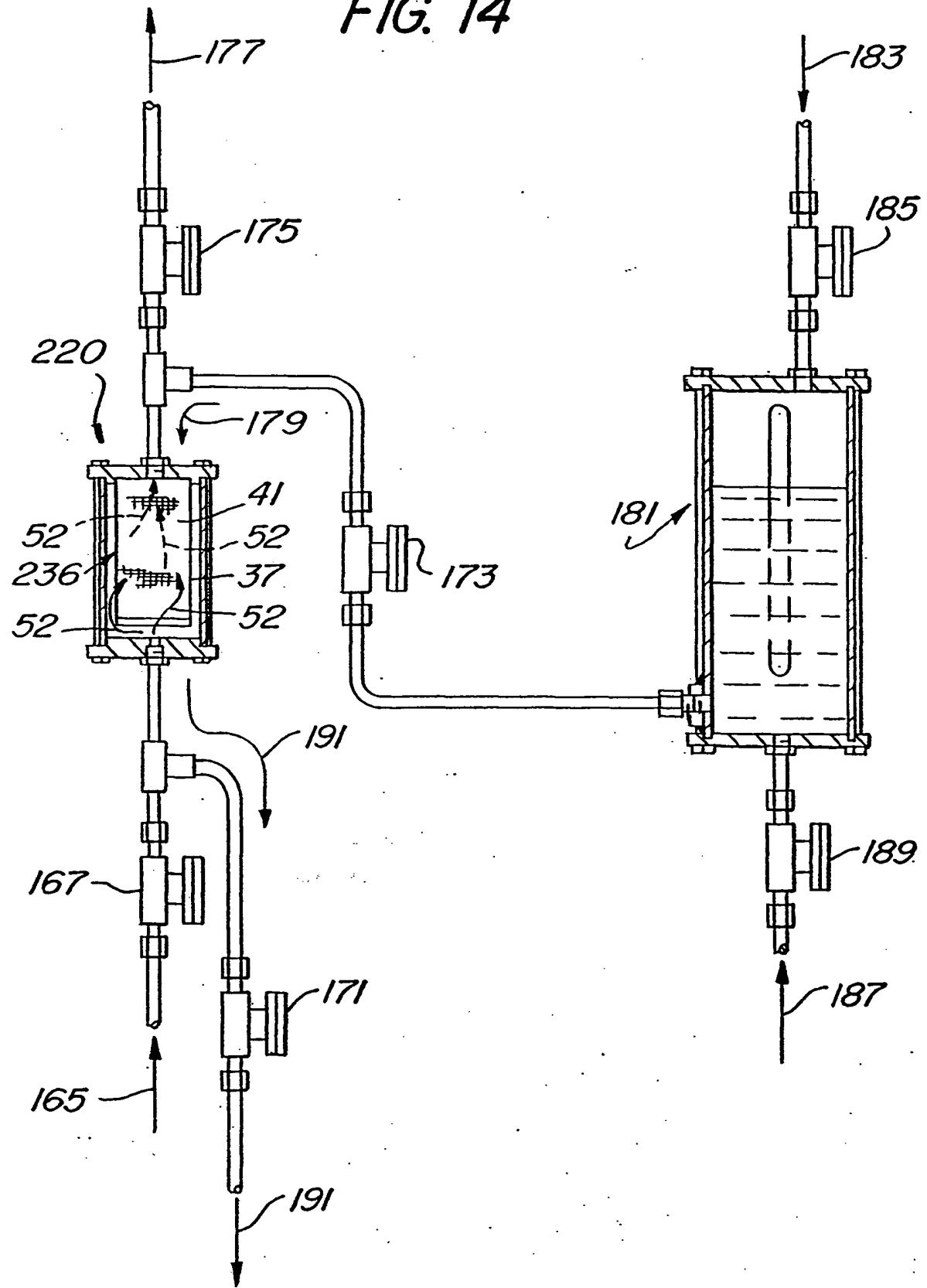


FIG. 15

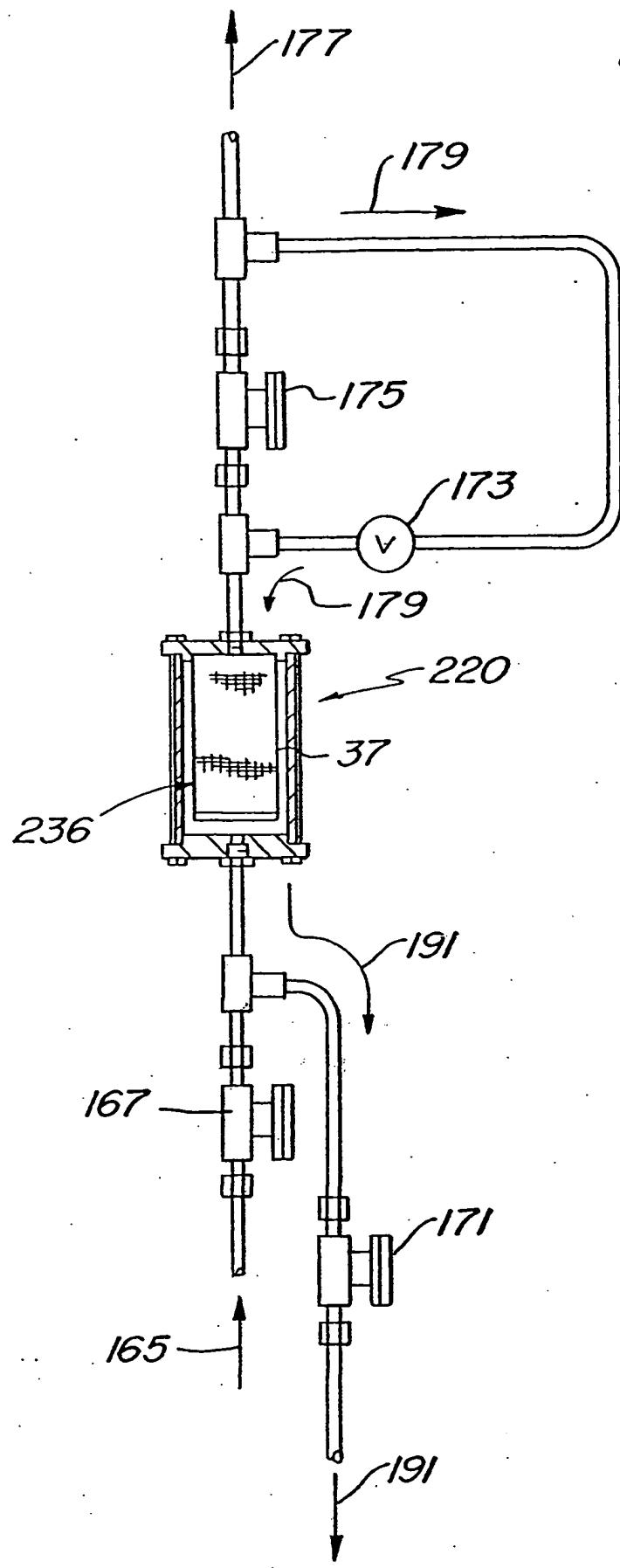
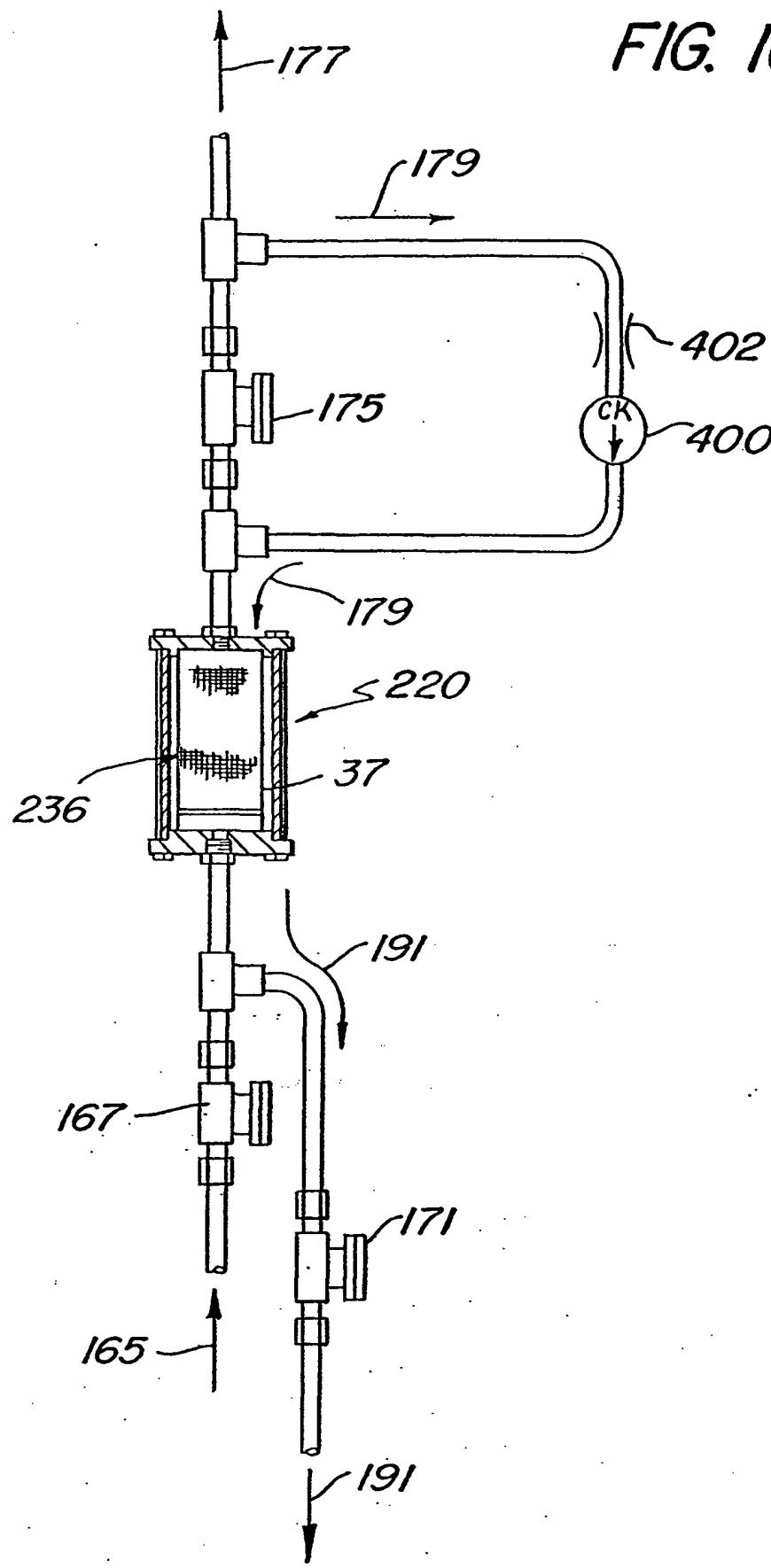


FIG. 16



INTERNATIONAL SEARCH REPORT

International Application No.

PCT/US 00/27955

A. CLASSIFICATION OF SUBJECT MATTER
 IPC 7 B01D29/15 B01D29/64 B01D29/68

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
 IPC 7 B01D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	EP 0 049 746 A (KLOECKNER HUMBOLDT DEUTZ AG) 21 April 1982 (1982-04-21) page 8, line 12 - line 21; claims 1-7; figure 3D ---	1-18, 26-30
A	EP 0 858 824 A (MANN & HUMMEL FILTER) 19 August 1998 (1998-08-19) the whole document ---	1-18, 26-30
A	US 5 595 655 A (JACKSON RICKY L ET AL) 21 January 1997 (1997-01-21) cited in the application the whole document ---	1-18
X	US 3 414 129 A (MERSFELDER ROBERT E ET AL) 3 December 1968 (1968-12-03) figure 1 ---	19-25 -/-

 Further documents are listed in the continuation of box C. Patent family members are listed in annex.

• Special categories of cited documents :

- "A" document defining the general state of the art which is not considered to be of particular relevance
- "E" earlier document but published on or after the International filing date
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"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

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Date of the actual completion of the international search

8 May 2001

Date of mailing of the international search report

15.05.2001

Name and mailing address of the ISA
 European Patent Office, P.B. 5818 Patentlaan 2
 NL - 2280 HV Rijswijk
 Tel. (+31-70) 340-2040, Tx. 31 651 epo nl,
 Fax: (+31-70) 340-3016

Authorized officer

De Paepe, P

INTERNATIONAL SEARCH REPORT

Inte nal Application No

PCT/US 00/27955

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	DE 462 348 C (GENTER THICKENER CO) 9 July 1928 (1928-07-09) the whole document ---	19-22, 24,25
X	GB 2 048 098 A (TAKUWA CO LTD) 10 December 1980 (1980-12-10) figure 1 ---	19-22, 24,25
X	EP 0 919 270 A (MANN & HUMMEL FILTER) 2 June 1999 (1999-06-02) figure 1 ---	19,20, 22,24,25
X	US 5 772 867 A (DU JUSUF-UTOMO ET AL) 30 June 1998 (1998-06-30) column 3, line 30 -column 4, line 2 ---	19-22, 24,25

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US 00/27955

Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This International Search Report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. Claims Nos.: because they relate to subject matter not required to be searched by this Authority, namely:

2. Claims Nos.: because they relate to parts of the International Application that do not comply with the prescribed requirements to such an extent that no meaningful International Search can be carried out, specifically:

3. Claims Nos.: because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

see additional sheet

1. As all required additional search fees were timely paid by the applicant, this International Search Report covers all searchable claims.

2. As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.

3. As only some of the required additional search fees were timely paid by the applicant, this International Search Report covers only those claims for which fees were paid, specifically claims Nos.:

4. No required additional search fees were timely paid by the applicant. Consequently, this International Search Report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

The additional search fees were accompanied by the applicant's protest.

No protest accompanied the payment of additional search fees.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. Claims: 1-18, 26-30

A fuel oil cleaning device comprising a porous member, a movable particulate-removing means and a drain for the removal of the dislodged particles. This means contains a chamber having walls extending along the length of the porous member, an apertured partition dividing said chamber in subchambers.

2. Claims: 19-25

A fuel oil cleaning system comprising a porous member, inlet and outlet valves controlling the reverse flow and a drain for the dislodged particles.

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

PCT/US 00/27955

Patent document cited in search report		Publication date		Patent family member(s)		Publication date
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